SPICES

By John W. Parry

Volume 1. The Story of Spices; The Spices Described

Volume 2. Morphology, Histology, Chemistry

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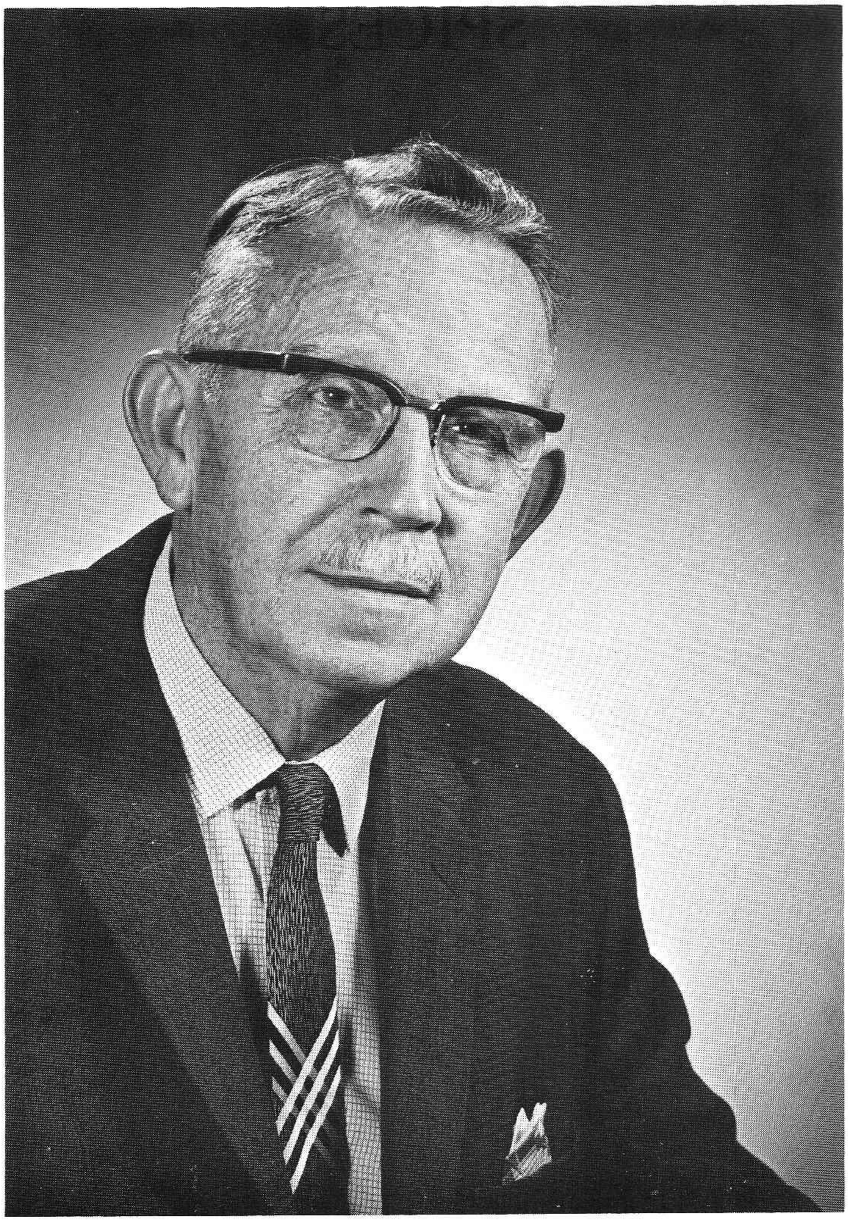

John W. Parry

SPICES

Volume I

The Story of Spices

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The Spices Described

by

John W. Parry

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Dedicated
to the memory of my mother
ANN ELIZABETH PARRY

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THE SPICE FAMILY

NOT a botanist's family, but a spice merchant's family—the group of aromatic and pungent products of which the goods of spice merchants throughout the world are composed. It is about these that this story is written. All their names follow. And for those who wish to know something about the spice plants, they are described in Part 2 of this book.

Allspice
Anise
Black Pepper
Capsicum Spices [Chillies, Cayenne, paprika pods]
Caraway
Cardamom
Cassia
Celery
Chervil
Cinnamon
Cloves
Coriander
Cumin
Dill
Fennel
Fenugreek
Garlic
Ginger
Laurel Leaves
Mace
Marjoram
Mint
Mustard
Nutmeg
Onion
Origanum
Parsley
Poppy Seeds
Rosemary
Saffron
Sage
Savory
Sesame
Star Anise
Tarragon
Thyme
Turmeric

PROLOGUE

IN a brightly illuminated and well-organized groceteria of a local department store, we noticed a woman shopper gazing at rows of neatly arranged, colorful, sifter-type containers. The little tins were filled with cinnamon, cloves, ginger, nutmeg, mace, pepper, sage, paprika, marjoram, and all the other delightfully aromatic and pungent spices which help milady to please her family and friends with the choicest of delectable dishes. She stood a long time, probably saying to herself, "I've got enough cinnamon and nutmeg, but I must have some cloves for the spice cookies, some sage for the dressing, yes—and hubby likes his poached eggs dusted with paprika and I'm out of that," and so on. Maybe she was just wondering about spices—where they came from; the history behind them. Perhaps she was seeing, in the kaleidoscopic array of fascinating names and multicolored labels before her, the panorama of the spices.

If she was, she saw in the passing scenes: Primitive men attracted to the spice plants by their alluring scent; Ishmaelite traders leading camels burdened with bales of spices along the road from Gilead to Egypt; the children of Israel preparing the anointing oil from the chief of all spices for use in the tabernacle; ancient Egyptians pounding spices, in stone mortars, with which to embalm their dead; Egyptian and Babylonian priests crushing spices to obtain fragrant oils for offerings in holy ritual to their gods; weary Egyptian laborers, resting from their task of building the Great Pyramid, munching on garlic; slow-moving camels bearing the spice gifts of the Queen of Sheba to wise King Solomon; and the guests of Solomon drinking spiced wine at his magnificent banquets.

She saw: Spices growing in the gardens of Babylon; busy spice traders in the hot and dusty market squares of that ancient city; bales of spices piled high on rafts moving slowly along the Euphrates and Tigris rivers; spice caravans winding their way across hot desert sands from Arabia "the blest" to distant points in all parts of the Middle East; Arabs, drowsy from the heavy odor of aromatics, plying a jealously guarded spice trade.

Physicians of the ancient world applying spice balms to the wounds of warriors, or easing the pains of the sick with doses of grateful aromatics; Egyptian ladies perfuming their bodies with the fragrant fumes of cinnamon; the preparation of scented oils and unguents from sweet-smelling spices; mighty oriental kings and princes presenting gifts of costly spices to great temples; Eastern lovers nestling in the sweet odors of the aromatics.

Victors in ancient games crowned with wreaths of laurel leaves before appauding multitudes; maidens pinning sprigs of anise to pillows to keep away disagreeable dreams; Persian mothers planting sweet basil on the graves of departed sons.

Staunch little spice-trading ships swept by warm monsoons to the Malabar coast of India; bags of pepper passing through the customs of the great Kublai Khan; Marco Polo shopping in the spice markets of the magnificent city of Hangchow.

Bales of spices arriving by boat or camel train in the markets of Hormuz, Bagdad, Constantinople, Alexandria, and Venice; busy merchants, in a babel of tongues, buying and selling precious aromatics.

The beautiful canal city of Venice grow rich from trafficking in spices; Portugal enviously watching her from afar.

Prince Henry the Navigator in his Sagres study conferring closely with skilled navigators, astronomers and cartographers, and pouring over charts, plotting routes that might lead to the Eastern spice lands; busy workmen in Portuguese shipyards turning out sturdy little caravels with which to bring the spices to Lisbon from India.

She saw: Daring navigators sail from Portuguese ports to discover island after island, cape after cape, as they push southward on the trail of the spices; the triumph of Bartholomew Diaz when his ship doubled the Cape of Good Hope; Vasco da Gama greet the prince of Calicut, and return to Lisbon with the first Indian spices carried over an all-water route from India to Portugal; the joy and enthusiasm of Portugal; the crestfallen face of Venice.

Christopher Columbus make his first voyage across the Western Ocean and discover the New World in his search for the spice lands.

Albuquerque the Great attack Hormuz, Aden, and the Malabar ports of India in his struggle with the Moslem world for supremacy over the spice trade; his conquest of the ancient spice port of Malacca; his expeditions to the Moluccas, Burma, Siam, and China, in his attempt to bring all the spice-producing lands and trading ports under the dominance of Portugal.

Ferdinand Magellan sail through the straits he discovered in his quest for the Spice Islands; his death in battle at Matan; his surviving ships *Trinidad* and *Victoria* reach the Moluccas; *Victoria* arrive in the harbor of Seville heavily laden with cloves—the first ship to circumnavigate the world!

Sir Francis Drake sail through Magellan's straits and bring his famed *Golden Hind* safely to the Spice Islands, make the first spice-trading contract in behalf of England, and duplicate the feat of the Spanish *Victoria* in circumnavigating the world; Sir Thomas Cavendish follow the aromatic trail to the Moluccas and accomplish the third circumnavigation of the world.

Cornelius Houtman reach Java and stake the interests of the Netherlands in the coveted spice producing islands of the East Indies; Van Neck bartering with haggling native merchants at Bantam for cargoes of pepper and nutmegs.

The founding of the English East India Company under the seal of Queen Elizabeth, its efforts in the Spice Islands and on the Malabar coast of India, and its subsequent domination of India; the founding of the Dutch East India Company and its victory over the Portuguese and English in the East Indies.

All these things, and much more, would she see, for all these things, and much more, are found in the story of the spices.

Part 1

THE STORY OF SPICES

I. SPICES IN THE ANCIENT WORLD

IN the beginning, untouched and undisturbed save by the hand of God, the cumin and the anise of Egypt gave up their scent to the gentle Mediterranean breezes which cooled that arid land. In neighboring Asia, sweet marjoram grew and unknown monsoons brought rains to wet the cardamom and cinnamon of Malabar and Ceylon, while away in the volcanic islands of the Moluccas the fragrant cloves and nutmegs were fruiting on the mountain sides. How long it was before man, struggling through the mists of the primeval world, came to know and use these and all other aromatic plants, we cannot tell, but he must have gathered early the leaves, fruits, seeds, and roots of fragrant herbs common to his locality and attributed to each a special virtue in his clouded scheme of things.

Primitive man would know nothing about cooking, but he would have his likes and dislikes for foods as we have today. He would choose his food plants for their smell and taste; the sweet flavored herbs would be preferred, and the bitter ones rejected.

Roaming through the woods in search of food, he would suffer injury from thorns and nettles; rotten trees lying on the wet forest floor would crumble under his foot, and he would stumble and bruise himself. He would suffer accidents and wounds while hunting wild beasts. And he would have times of sickness and bodily pain from diseases he could not understand. In his distress, he would turn to the fragrant oil-bearing spice plants, intuitively sensing that those herbs which are so pleasant to the nostrils must also be healing to his wounds and grateful to his sickness.

He would marvel at the sun during the day and at the moon and stars during the night; at daylight and darkness; at sky and water. He would think of them as good or bad, and thus affected he would come to believe them gods of virtue or evil. From raging storms he would seek shelter in natural caves, where, with fastbeating heart and perplexed mind, he would cower from the downpour of the tempest, the brattles of thunder, and the terrifying flashes of lightning. In the darkness of his earthy refuge he would conjure up fearsome creatures in an exaggerated and frightful image of himself, and he would believe them responsible for these natural manifestations. He would seek to appease the fearful demons, and he would want to please the virtuous gods of his imagination. And he would do so by making offerings of the sweet-smelling spices in the belief that those which so delighted him must also delight the gods.

And so, no doubt, began the uses and customs which have endured through the ages—spices for food, spices for healing, and spices to placate the gods.

Beyond these assumptions about the thoughts and practices of primitive man we cannot go. The stone implements and cave drawings tell us something about these early people and indicate the observing and inventive nature of their minds, but give us nothing on which to base the story of the spices in those very remote times. Not until after the passage of thousands of years did men develop a system of writing, and for the earliest records, we must go to the fertile valleys of the Euphrates, the Tigris, and the Nile.

Out of the darkness of unrecorded time came the Sumerians to southern Mesopotamia. A nonsemitic people of unknown origin, their civilization was highly developed, and by about 3300 B.C. they had devised a system of writing. The Mesopotamian earth was well adapted to molding, and the Sumerians made cylinders and tablets of clay on which they inscribed their wedge-shaped letters. Politically, their territory was divided into a number of city states, each ruled by a priest king known as a "Patesi." The leading Sumerian cities were Nippur, Lagash, Larsa, and Ur.

Among the Semitic peoples who settled to the north of Sumer were the Akkadians, whose chief cities were Babylon and Kish. The land of Sumer and Akkad became the country of Babylonia. Out of Kish came Sargon who subdued Sumer, built the city of Agade, and extended his sway from the Persian Gulf to the Mediterranean. Through the centuries, Babylonia knew many wars and political upsets, and produced a number of great kings including the brilliant Khammurabi, whose name is famed for his monumental Code of Laws.

In the north, on both sides of the Tigris, a warlike people, the Assyrians, established themselves about 3000 B.C. Their chief cities were Ashur and Nineveh. For centuries, these people were in conflict with Babylonia and other places and peoples, and eventually became a great power in the Middle East. Among the great kings of the Assyrian Empire, the most notable were Sargon II, Sennacherib, Esarhahhon, and Ashur-bani-pal.

The gods of these early Mesopotamian peoples, like the gods we supposed to have existed for primitive man, represented natural phenomena as, for example, *Shamash* the sun-god, *Sin* the moon-god, *Anu* the sky-god, and

Ea the water-god.

A series of tablets, now in the British Museum, give the Assyrian account of the creation of the world. They describe the conflict between Apsu and Tiamat, the male and female deities of the primeval watery mass, on the one side, and the newly created gods representing order and system in the universe, on the other. Apsu was destroyed in battle, but Tiamat remained unconquered and created a brood of terrible monsters to battle the gods of order. An appeal was made to the great god Marduk who agreed to fight Tiamat, provided he was elected champion of the gods. A meeting of the gods was held in their council chamber where "they ate bread, and they drank sesame-wine." Marduk was elected champion of the gods and in due course, riding in his four-horsed chariot, he proceeded against Tiamat and pierced her with his spear. He then split her in half and formed the heavens from one half, and the earth from the other. Here, in the beginning, we have the Assyrian gods drinking a wine made from a spice. Nothing could emphasize the importance of spices to the ancients more than this story. Vegetation could not grow before the earth was created, yet sesame already existed!

Sesame was a source of food, wine, and oil, and its production was a matter for royal supervision and attention. In two letters, this spice was the subject of instructions from the great Khammurabi to Sin-idinnam, governor of Larsa. In one, Khammurabi instructs the governor of Larsa to send to Babylon two customs officers with sesame seed, under the escort of a trustworthy guard; in the other, Sin-idinnam is informed that one Shunurkhali has been dispatched to Larsa to bring back to Babylon a quantity of sesame seed, which he is to have packed and ready for export.

In later years, this seed was often a subject of contract and accounting, as is shown by the references to sesame on tablets and deeds now in the Babylonian room of the British Museum. One of these covers a loan of silver and sesame seed; another records an allowance of food, drink, and sesame seed, to be paid by one Na'id-Marduk to his wife and son; and still another covers a loan of silver and sesame seed from one Nubta to one Ittl-Marduk-balatu. There is also a tablet of accounts concerning dates and sesame seed. All belong to the 6th century before Christ.

Throughout the years of Babylonian history, sesame seed was highly prized for its practical uses. It found favor for the making of sesame cakes, dainties, wine, and brandy. Sesame oil was used as a food, in medicine, and in the preparation of toilet requisites. Its skin-soothing properties made it most acceptable for oiling the body, and it was an excellent vehicle for perfumes. Herodotus, Greek historian (c. 484—425 B.C.), said it was the only oil used by the Babylonians. And Theophrastus, Greek scholar and famed plant student (c. 372—288 B.C.), commenting on sesame oil said it was "specially receptive" for the making of perfumes, and particularly rose perfume "because of its viscid quality; and, when subjected to fire, it gives out a smell of sesame."

According to Herodotus, on one occasion, sesame prevented the castration of a number of innocent boys. Periander, Tyrant of Corinth (665—585 B.C.), forcibly sent three hundred sons of noble Corcyraean families to Ayattes to become eunuchs. On their way to Sardis, their guards put in at Samos, and the Samians learning what was in store for the boys hurried them into the temple of Diana where they took sanctuary. Since the Corinthian guards could not enter the temple and take the boys, they stopped food supplies from reaching them. To prevent the boys being forced to surrender through hunger, a festival was originated by the Samians which called in part for choirs of youths and virgins to stand about the temple holding cakes of sesame in their hands which the unfortunate boys might snatch. The observance of the festival was kept going for so long a time that the Corinthian guards gave up their vigil and left the city, and then the Samians returned the boys to their parents in Corcyra.

The Babylonians grew many spices in their gardens. The Hanging Gardens of Babylon, which may have been gardens supported on arches as depicted on a slab now in the Assyrian Saloon of the British Museum, were most probably decorative flower gardens lending beauty to an already magnificent city, but besides these, many large gardens existed for the production of sweet-smelling herbs. In fact, such gardens were an important part of Babylonian economic interests.

Both Babylonians and Assyrians took a keen interest in natural science and observed the growth and physiology of plants very carefully. Long lists of plants were compiled for the use of doctors and magicians, and many of the drugs used in their systems of medicine were derived from spice herbs. Assyrian doctors and chemists were particularly well informed on the medicinal properties of herbs, and among the two hundred or so plants known to them, cardamon, cumin, dill, fennel, origanum, thyme, saffron, and sesame, have been identified.

In the garden of Merodach-Baladan II, King of Babylon (721—710 B.C., and 703—702 B.C.), grew cardamon, coriander, dill, garlic, onion, thyme, and saffron. King Sennacherib, son of Sargon II— he who captured Babylon in 689 B.C. and who perished at the hands of his two sons in 681 B.C. (Isaiah 37:38)—laid out great gardens and planted all kinds of herbs for his subjects. In the British Museum tablets may be seen from the royal library of Ashur-bani—pal (668—625 B.C.), on which are inscribed the names of numerous plants.

The aromatic plants were early employed in fumigation. It was natural that the sweet fragrance of the spices should have been associated with purity by the ancients. To them that which was foul-smelling would be a manifestation of evil, only to be combatted and overcome by the clean sweetness of the aromatics, and so, for cleansing purposes, the spices found great favor in the eyes of the priests. An early example of this might be that of Gudea, Patesi of Lagash (c. 2450 B.C.) who, in preparation for the building of a temple, purified the city by special rites and kindled a fire of aromatic woods to make a sweet savor for the gods. And it is probable that this was the beginning of the practice of using spices to fumigate the streets of cities before royal visits, and to ward off disease in times of plague as was done in Europe during the Middle Ages.

Spice plants played a part in many of the incantations, magical rites, and ceremonies performed by the priests in behalf of those plagued with sickness or suffering from spells and bewitchments. In the second tablet of the Maklu series of Assyrian incantations addressed chiefly to the Fire-god, the performance of the ritual was to be accompanied by the burning of the flower of sesame. In the fifth tablet, mint and cassia play a prominent part. In the sixth tablet of the Sharpu series, addressed to the god Marduk in behalf of a man whom a demon had plagued with sickness, the priest was to cast into the fire a pod of garlic, certain seeds, and other substances. In other series of incantations, sesame wine, pleasant odors, and oils were to be set before the gods if the suppliants were to gain absolution and purity. On the occasion of the illness of the Babylonian king Shamash-shum-ukin (668—648 B.C.), twelve sesame cakes were called for in the incantation for the hand-raising prayer to Sin, the moon-god. He recovered only to burn to death later in his own palace.

In their way of life, the Babylonians were a people fond of magnificence. They consumed lots of spices, and the spice trade was a major and lucrative business in Babylon. To her markets, the spices made their way by boat and caravan from widely separated points, and the merchandising of spices and spice products in this ancient city was great enough to merit mention with her trade in gold, silver, and precious stones, in the 18th chapter of The Revelation of St. John the Divine.

Now let us turn to Egypt. Following in the wake of the primitive people who inhabited the fertile banks of the Nile, thousands of years before the Christian era, the true Egyptians appeared. At first, they were a number of tribes or families scattered throughout Egypt, but later they became organized into two distinct kingdoms known as Upper and Lower Egypt. About

3400 B.C., these kingdoms were united and the dynastic period of Egypt began. In civilization and accomplishments, the Egyptians were not dissimilar from the Sumerians, and like them, they early found a means of making lasting written records. They did not have a clay suitable for molding, but they discovered a method of fastening together strips of papyrus reed on which they inscribed hieroglyphics with a brush.

The Egyptians believed in a self-existent, omnipotent god, but they also worshipped many other gods. *Ra* was their sun-god, *Geb* their earth-god, *Nut* their sky-god, and so on. Many of their gods were thought to live in the bodies of animals, such as the ram, bull, cat, dog, and cow. Their most important gods were those of the dead and among these Osiris was supreme. Osiris absorbed the attributes of the god of vegetation, and was skilled in the knowledge of plants. The Egyptians believed the spirit returned to the body of the deceased and, as far back as the 4th millennium before Christ, the bodies of kings and other highly placed persons were preserved against decay after death by a system of mummification which, in time, became quite elaborate. The spices first used in the mummifying process may have been anise and cumin and perhaps sweet marjoram. Later, when cinnamon and cassia found their way into Egypt, these two barks were among the chief embalming spices.

Herodotus tells us that there were three methods of embalming the body. In the first and most expensive process, carried out by experts, a portion of the brain was drawn out through the nostrils by means of a length of crooked wire, and the remaining brain tissue was washed out of the skull by repeated rinsing with drugs in solution. The body was then opened with a sharp stone knife, and after removing the contents of the abdomen the cavity was thoroughly washed with palm wine, and rinsed many times with an infusion of pounded aromatics. It was then filled with "the purest myrrh, cassia, and every other sort of spicery, except frankincense." Following this, the body was sewn up and placed in a sodium solution for seventy days. (It might be observed here that the period given in the Bible for the embalming of Jacob was forty days, while the mourning continued for seventy days. Genesis 50:2, 3.) The body was then wrapped in linen bandages from head to foot, smeared with gum, and returned to the relatives who put it in a wooden case made in the figure of a man and placed it upright against the wall of the sepulchral chamber.

Herodotus does not mention the use of cassia or other spices in his description of the second and third methods of embalming, which might indicate the high cost of spices, particularly those which had to be imported, in early Egyptian times. Cinnamon and cassia are not native to Egypt, and these spices could only arrive in that country after long transport and repeated handling, which must have made them very costly.

The ancient Egyptians, no less than their contemporaries in Mesopotamia, used the spices to make unguents, perfumes and holy oils. About 2500 B.C., Pharaoh Sankhkere sent ships to the land of Punt, which seems to have been the regions on both sides of the Lower Red Sea and the Gulf of Aden, and in 1500 B.C., the Egyptian queen, Hatshepsut, sent an expedition of five ships down the Red Sea to this land for aromatics. According to her records, the ships took on board a goodly cargo of "fragrant woods of God's land, heaps of myrrh-resin, of fresh myrrh trees...cinnamon-wood, with incense, eye-cosmetic..." All these fragrant substances were necessary in their way of life and for their rites and ceremonies. The dead were anointed with holy oils, and scented unguents had their place in Egyptian funeral ritual. Part of the Ritual of Embalmment reads:

> O thou deceased, the magical oil has come to thee to anoint thy mouth....It gives thee thy nose to breathe through, even as Geb breathed when he snuffed up sweet-smelling perfume of the finest quality.

The holy oils were seven in number, and named: Finest Oil of Libya, Finest Oil of Cedar, Tuatu, Nemnen, Sefth, Heknu, and Festival Oil. Some of these, we can be sure, were the oils of spices.

In the British Museum, there are numerous vases, bowls, pots, etc., which were containers for scented unguents and perfumes in use from the 3rd to the 26th dynasties. There is also a series of vases inscribed with the names of drugs, medicines, and unguents, which, it is thought, belonged to an apothecary's store. They were found in a chamber near a tomb of the 6th dynasty.

Only the spices could have supplied the delicate fragrance which appealed so strongly to these ancient people, and the high esteem in which such scents were held is shown in the following words from the Song of Harper, composed in the reign of Antuf, a king of the 11th dynasty:

> Immerse thyself in precious perfumes,
> Which are the veritable products of the gods.

This song is found in the Harris Papyrus 500, which also gives us the words of an Egyptian love song in which the lover compares the lady of his choice to "many beautiful flowers and aromatic plants."

Herodotus tells us a story which further emphasizes how closely the spices were associated with the everyday habits and customs of the ancient Egyptians. Mycerinus, a king of Egypt in the 4th dynasty, lost his only child, a daughter. In his great sorrow, Mycerinus wished to entomb his child in some unusual way, so he had a wooden image of a cow built, with the inside hollowed out and surfaced with gold. In this odd tomb he placed the body of his daughter and set it up in a richly adorned chamber of the royal palace, and "every day there are burnt before it aromatics of every kind."

Kings of ancient Egypt erected huge stone pyramids to serve as their tombs. The largest of these is the Great Pyramid at Gizeh, standing 451 feet high and covering thirteen acres, built by King Khufu, called Cheops.* According to Herodotus "one hundred thousand men labored constantly, and were relieved every three months by a fresh lot" during the twenty years it took to shape and put together its 2,300,000 blocks. And the diet of those toiling workers, sweating in the rays of the hot Egyptian sun, was largely made up of garlic and onions. Herodotus tells us that "there is an inscription on the pyramid which records the quantity of radishes, onions, and garlic, consumed by the laborers who constructed it." From this we get an excellent idea of the importance of the spices garlic and onion as a food for the common people of that ancient land.

As already said, the spices were esteemed in those times for their medicinal uses, and some names of members of our spice family appear in the Medical Papyrus of Thebes, written in 1552 B.C., and discovered by the German Egyptiologist George Moritz Ebers (1837—1898). This scroll lists several hundred remedies, and among the plants identified appear the names of coriander, caraway, sesame, and saffron. Other spices are doubtless included, but as a translation of all the ancient Egyptian plant names has apparently not been possible, we must remain in ignorance concerning their identity.

The spices filled much the same role in relation to food, drinks, unguents, perfumes, medicine, and religious ritual in ancient Egypt as they did in Babylonia and Assyria, and this storied land was an equally great market for merchants dealing in imported spices. With the passage of time, the spice trade grew in importance and such cities as Thebes, Memphis, and Coptus became notable as marketing and distributing centers for spices. In due course, the great city of Alexandria came into existence and remained the leading emporium for the trade in oriental spices until the ascendancy of the Portuguese in the 16th century anno Domini.

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* Formerly thought to have reigned in the fourth millenium B.C., now generally believed to have done so in the third, probably around 2700 B.C.

II. SPICES IN THE HOLY BIBLE

PASSAGES of the scriptures throw additional light on the history and uses of the spices in the ancient world. The first mention of spices in the Holy Bible is found in the Book of Genesis, chapter 37, in connection with the story of Joseph. Just when Joseph lived nobody knows exactly, but according to a leading authority on dates, his great-grandfather Abraham, the patriarch of the Hebrew people, was born 1997 B.C. Abraham left the ancient Sumerian city of Ur to dwell in the land of Canaan in the year 1921 B.C. He was 100 years old when his son Isaac was born; Isaac was 60 years old when his son Jacob was born, and Jacob is said to have been 91 years old when his son Joseph was born. As Joseph was 17 when he was sold to the Ishmaelites, the first Bible reference to spices would be associated with an incident that took place in the year 1729 B.C.

When Joseph was born, his father Jacob was an old man, and because of this, Jacob loved him more than all his other children and made him a coat of many colors. When Joseph's brothers saw that their father so loved and favored him, they became jealous and full of hate for Joseph. This unhappy condition was aggravated when they learned that certain prophetic visions had come to Joseph in his sleep, and they conceived a dastardly plot to destroy him. Their plan was to slay the innocent lad, dispose of his body by casting it into some distant wilderness pit, and tell their father that Joseph had been devoured by a wild beast. But brother Reuben shrank from the thought of murder and persuaded them to shed no blood, but to cast Joseph into a pit, "and lay no hand upon him." Acting on this advice, the brothers seized Joseph, divested him of his coat of many colors, and lowered him into a dry pit. They then sat down to eat bread:

> And they lifted up their eyes and looked, and, behold, a company of Ishmeelites came from Gilead with their camels bearing spicery and balm and myrrh, going to carry it down to Egypt.

This gave the brothers a new idea, and instead of abandoning the lad, they sold him to these travelling spice merchants for the sum of twenty pieces of silver. After this inhuman transaction the brothers killed the kid of a goat and dipped Joseph's coat in its blood. Returning to their father they told him that they had found the blood-soaked coat and asked if he recognized it, to which Jacob replied that it was his son's coat, and concluded in his great sorrow that "an evil beast hath devoured him." The spice merchants sold Joseph in Egypt to Potiphar, an officer of Pharaoh.

From this story, we get an idea of the great age of the spice trade. We are not told the nature of the spices carried by the camels of the Ishmeelites, but it is not unlikely they were imported spices to meet the demand of Egyptian royalty for rare aromatics. And it is probable that the Ishmeelite traders were following a caravan route already old and carrying spices which had been transshipped to Gilead from some point on the Euphrates, to where they had been conveyed by boat or raft from the Persian Gulf.

In Genesis 43, spices are mentioned again in connection with the story of the life of Joseph. Pharaoh had a dream which he did not understand and which Joseph interpreted as foretelling seven years of plenty and seven years of famine in the land. When the famine came to the land of Egypt, the people were fed from the great store of corn which Joseph had gathered during the seven years of plenty. But the famine was widespread and the people of the neighboring countries, including the land of Canaan, were without food and in sore distress. Jacob hearing of the corn in Egypt sent his sons there to buy a supply to keep them from starvation. When it was consumed, Jacob sent them a second time saying to his sons, "carry down the man [Joseph] a present, a little balm, and a little honey, spices, and myrrh, nuts, and almonds." This is indicative of the high value set on spices by the people of those days. Joseph had become a power in the land of Egypt, and a gift to one so highly placed must consist of those things which were agreeable and delightfully acceptable.

In the Book of Exodus, spices are mentioned in the story of the wanderings of the children of Israel. In Exodus 16:31, manna, the bread which Moses told the children of Israel the Lord had sent down for them to eat, is compared with coriander seed in color. From this we see that coriander was well known to the ancient Hebrews.

The Lord spoke to Moses on the top of Mount Sinai and gave instructions that the children of Israel should build a tabernacle that He might dwell among them. First, they were to bring an offering of "oil for the light, spices for anointing oil, and sweet incense" (Exodus 25:6). Then, for the making of "an holy anointing oil" with which to anoint the tabernacle, Moses was told to use cinnamon and cassia with other substances:

> ...Take thou also unto thee principal spices of pure myrrh five hundred shekels, and of sweet cinnamon half so much, even two hundred and fifty shekels, and of sweet calamus two hundred and fifty shekels,
> And of cassia five hundred shekels, after the shekel of the sanctuary, and of oil olive an hin:
> And thou shalt make it an oil of holy ointment, an ointment compound after the art of the apothecary: it shall be an holy anointing oil. (Exodus 30:23, 24, 25.)

And for the preparation of a perfume to be put "before the testimony in the tabernacle of the congregation" (Exodus 30:36) Moses was told:

> ...Take unto thee sweet spices, stacte, and onycha, and galbanum; these sweet spices with pure frankincense: of each shall there be a like weight:
> And thou shalt make it a perfume, a confection after the art of the apothecary, tempered together, pure and holy. (Exodus 30:34, 35.)

In Exodus 35:8, Moses repeats the first of these instructions to the children of Israel, and in Exodus 37:29, we read that the holy anointing oil and perfume were made according "to the work of the apothecary" as the Lord had commanded.

In these passages we have the first Bible references to cinnamon and cassia. Haydn gives the date of the building of the tabernacle as 1490 B.C., and there is nothing in the Bible text which would lead us to believe that these spices were not well known to the Hebrews at that time. We would conclude from the language of the text that spices had long been used by Hebrew apothecaries for the making of scented unguents and holy oils, and that of all spices, cinnamon and cassia were held in highest esteem.

The use of spices by the ancient Hebrews to make perfumed ointments and oils would not be different from that of the Babylonians, Assyrians, and Egyptians, contemporary with them, and long before them.

In Exodus 30:23, myrrh, and sweet calamus, are spoken of as spices; and in Exodus 30:34, stacte, onycha, and galbanum are called "sweet spices." None of these is included in the modern spice family. Myrrh and galbanum are aromatic gum resins secreted by plants found in the Middle East. Sweet calamus is a perennial plant found in Asia, Europe, and America. Its common name is sweet flag and its leaves and rhizomes are aromatic. Polybius, Greek historian (c. 208 B.C.), speaking about a decree passed by the Gerrhaeans which honored Antiochus with a gift of silver, frankincense, and "so-called stacte," infers the latter to have been a spice product of the Persian Gulf. It may have been an oil of cinnamon or cassia, or it may have been an aromatic gum resin other than those already mentioned here, but actually nobody knows what it was. Onycha is said to be the operculum of a species of mollusk found on the coast of the Red Sea, which when burnt gives off a strong aromatic odor. The Arab women of Nubia and Upper Egypt are said to burn onycha, ginger, cloves, cinnamon, and other substances on a small charcoal fire set in a hole in the floor to produce scented fumes in which they bathe their bodies.

In the eleventh chapter of the Book of Numbers, we find the children of Israel dissatisfied, and complaining about the lack of food. They remind Moses that, when in Egypt, they had eaten freely of fish, cucumbers, melons, leeks, *onions*, and *garlic*. This is another indication of the importance of garlic and onions in the diet of the ancient Egyptians. In this chapter, manna is again compared to coriander seed.

We get further proof of the great value of spices as gifts to people in exalted positions in those early times from I Kings 10. Solomon, king of Israel (1015—977 B.C.), was renowned for his wisdom and, on one occasion, the queen of Sheba "came to prove him with hard questions." "And she came to Jerusalem with a very great train, with camels that bare spices," which we are told were of such a quantity that "there came no more such abundance of spices as those which the queen of Sheba gave to king Solomon." This visit and gift of spices is again commented on in II Chronicles 9.

Solomon was not only a very wise king, but a very rich one, and part of his great yearly income was derived from "the traffick of the spice merchants" (I Kings 10:15). And in addition, all those who sought to hear him brought costly presents including spices (I Kings 10:25).

Another wealthy monarch of Biblical days was Hezekiah, king of Judea. In II Chronicles 32:27, we read of his great wealth of silver, gold, precious stones, and spices. In II Kings 20, we learn of his sickness, and of Berodach-baladan, the son of Baladan, king of Babylon, sending him letters and a present. To the messengers of Berodach-baladan who brought the letters and gift, Hezekiah showed all the treasure of his house including his store of spices and precious ointments (verses 12, 13). That spices are coupled with rare metals and precious stones and counted in the treasure of a king is proof of their great worth in ancient times. We wonder how much the gifts of spices to royal personages determined the course of history in those days. The spices of Hezekiah are also mentioned in Isaiah 39:1,2.

In II Chronicles 16:14, there is an interesting reference to the use of spices in connection with the burial of Asa, king of Judea, who resoundingly defeated the Ethiopian Zerah and his host of "a thousand thousand, and three hundred chariots" in the valley of Zephatah at Mareshah and who died at thirty-nine of a disease of the feet! Unlike the Egyptian practice of packing the abdominal cavity of the departed one with spices, the "sweet odors and divers kinds of spices" filled the bed in which Asa lay in the sepulchre. Spices were similarly employed in the burial of Christ, as described in the gospel of St. John:

> Then took they the body of Jesus, and wound it in linen clothes with the spices, as the manner of the Jews is to bury (chapter 19, verse 40).

In Psalm 45, cassia is a perfume of the loved one:

> All thy garments smell of myrrh, and aloes, and cassia, out of the ivory palaces, whereby they have made thee glad. (verse 8.)

Exquisite perfumes have always played an enticing role in love making whether of the honorable or base kind. In the seventh chapter of Proverbs, we have an example of the latter in the story of the lady of easy virtue who uses the sweet odor of cinnamon to ensnare "a young man void of understanding." The empty-headed young man is coaxed and persuaded by the woman "with the attire of an harlot" to come to her bed which had been perfumed with "myrrh, aloes, and cinnamon" and take his "fill of love" until morning. It might be as well to record the admonishment of Solomon, "her house is the way to hell, going down to the chambers of death."

In the beautiful passages of The Song of Solomon there are many references to spices:

> How fair is thy love, my sister, my spouse! how much better is thy love than wine! and the smell of thine ointments than all spices! (chapter 4:10.)
> Thy plants are an orchard of pomegranates, with pleasant fruits; camphire, with spikenard, Spikenard and saffron; calamus and cinnamon, with all trees of frankincense; myrrh and aloes, with all the chief spices: (chapter 4:13,14)
> Awake, O north wind; and come, thou south; blow upon my garden, that the spices thereof may flow out. (chapter 4:16.)
> I am come into my garden, my sister, my spouse: I have gathered my myrrh with my spice; (chapter 5:1.)
> My beloved is gone down into his garden, to the beds of spices, to feed in the gardens, and to gather lilies. (chapter 6:2.)
> I would lead thee, and bring thee into my mother's house, who would instruct me: I would cause thee to drink of spiced wine of the juice of my pomegranate. (chapter 8:2.)
> Make haste, my beloved, and be thou like to a roe or to a young hart upon the mountains of spices. (chapter 8:14.)

Here we have further evidence of the interest taken in gardens, and the cultivation of spices by the ancients. And we gather from the fifth quotation that spiced wine was a beverage common to them, as, we shall learn later, it was to the people of the Far East.

Cumin was well known to the ancients, and this spice is mentioned in the 28th chapter of Isaiah:

> When he [the plowman] hath made plain the face thereof, doth he not cast abroad the fitches, and scatter the cummin,...? (verse 25.)
> For the fitches are not threshed with a threshing instrument, neither is a cart wheel turned about upon the cummin; but the fitches are beaten out with a staff, and the cummin with a rod. (verse 27.)

Ezekiel 27:19, 22, speaks of the trade of the great Phoenician city of Tyre:

> Bright iron, cassia, and calamus, were in thy market....The merchants of Sheba and Raamah, they were thy merchants: they occupied in thy fairs with chief of all spices...

The New Testament does not speak so frequently of spices. In St. Matthew 13:31, Christ likens the kingdom of heaven to a grain of mustard seed, and in St. Matthew 17:20, He speaks of the power of faith even if it be no greater than as a grain of mustard seed. In the 23rd chapter of St. Matthew the names of mint, anise (said to mean dill), and cumin occur. The reference to spices in St. John 19:40, in connection with the burial of Christ, we have already cited.

The final reference to spices is found in The Revelation of St. John the Divine. The 18th chapter foretells the fall of the great city of Babylon and portrays the sore distress of the merchants of the world, who have been made rich from trading in the multitude of costly goods which were found in her markets:

> And the merchants of the earth shall weep and mourn over her;...And cinnamon, and odours, and odors, and ointments,... thou shalt find them no more at all.

These Bible references* emphasize the important place of the spices in the ancient world and the high esteem in which they were held; particularly is this true of the fragrant spice barks of cinnamon and cassia.

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* The Bible quotations in this chapter are from the authorized King James version.

III. CASSIA AND CINNAMON IN THE ANCIENT MIDDLE EAST

WE have seen that cinnamon formed part of the aromatics used by the Egyptian queen, Hatshepsut, some 3,500 years ago, and that cassia was employed in ancient Egypt to embalm the dead. And we have seen that cassia and cinnamon were ingredients of the holy annointing oils and perfumes used in the ritual of the tabernacle erected by Moses in the wilderness of Sinai. We have seen also that cassia was in the market of ancient Tyre, and that cinnamon was an item of merchandise in the old and magnificent city of Babylon. But cassia and cinnamon do not grow in those parts; the first is native to China and the East Indies, the second to Ceylon and the nearby Malabar coast of India. How, and by which people, then, did these fragrant spice barks first reach the Middle East?

The first parcels of cassia and cinnamon may have made their way across the continent of Asia by a slow-moving neighbor-to-neighbor trade along routes offering the least resistance to travel. A possible route from China would wind its way west between the mountain ranges of Kuen-Lun and Thian-Shan, through the valley of the Tarim river to Kashgar, then to Bokhara, and from there southward to the ancient port of Hormozia on the Persian Gulf, or to Bassorah (Basra) at the head of the Gulf. Another possible route from China would lead similarly to Bokhara and then continue westward through the ancient provinces of Parthia and Media to the rivers Tigris and Euphrates. A route from Northern India would lead from the Indus through the ancient province of Gedrosia to Hormozia and would continue from there through the ancient provinces of Persis and Susiana to Bassorah. As a matter of fact, routes from China and India, which may have followed these courses, are said to have existed from "time immemorial," but whether this means they were in existence over 1,500 years before the Christian era, is something we do not know. If they were, and if we allow a route from Southern to Northern India, it is not impossible that the first cassia and cinnamon came this way to the Middle East.

We do not, however, believe that in the first instance, or for some time afterward, cassia and cinnamon came by land to the Middle East. Difficult mountain ranges, swift-moving rivers, miles of barren plains and arid deserts, lack of provisions for traders and pasture for animals, the great distances between waterholes, the chill of mountain passes and the heat of the desert sun, all militate against the idea of caravan movements in such early ages. We have only to consider the frightful experiences of Alexander's army when it marched westward through Gedrosia from the Indus in the 4th century before Christ to realize how great would have been the difficulties of the land traveler centuries before that time. The coastal voyage of Nearchus, Alexander's famed admiral, from the Indus to the Persian Gulf was pleasurably simple by comparison.

History shows that wherever waterways existed, early peoples moved their burdens by raft or barge in preference to donkey or camel packing over land trails. The Sumerians built large barges and ships, and used them on the Tigris and Euphrates rivers and in the Persian Gulf to transport goods. In addition to ordinary trade voyages in home waters, it is most probable that they sailed their ships along the coast of South Arabia to the Red Sea to get the stone, wood, and copper, which they needed for the construction of their temples. The ancient Egyptians moved their merchandise along the Nile in barges, and sailed ships down the Red Sea and in the Mediterranean at a very early date. Some 4,500 years ago, Pharaoh Sankhkere sent ships down the Red Sea as far as the strait of Bab el Mandeb to obtain supplies of aromatics in the land of Punt. In short, there is enough evidence of the early use of ships for the transportation of merchandise to warrant the conclusion that the ancients found the difficulties of river and sea passage very much less than those of land. And the continued use of ships and increasing knowledge of the sea would inevitably lead to the longer voyages which brought the spices of India to the Middle East more than 3,500 years ago.

Now we come to the second part of our question, namely: By which people did cassia and cinnamon first reach the Middle East. Of all the peoples of the ancient Middle East, only two stand out as probable founders of trade with Eastern spice lands: the Phoenicians and the Arabians.

The Phoenicians did not originate in the narrow tract of Syrian land overlooking the Mediterranean, which they inhabited in the days of the ancient Greeks and Romans. By their own account, according to Herodotus, they migrated from the shores of the Erythraean Sea, which is identified with the Persian Gulf. Why, or when, the migration took place, is not known. Phoenicia comes into history about 1500 B.C., although Sidon, their oldest city, was in existence at that time. Tyre seems to have been founded about that date.

Herodotus tells us that when the Phoenicians arrived on the Syrian coast, they began at once to venture on long voyages, carrying in their ships the merchandise of Egypt and Assyria. From this beginning they rapidly gained control of the trade moving between East and West, and became a great commercial and maritime power. By land they traded their famed Tyrian purple, fabrics, glassware, and objects of gold, silver, and bronze, for the products of the Middle East from Asia Minor to the Persian Gulf, by sea for those of Africa, Greece, Italy, Spain, Portugal and France. They early established trading stations at many points in the Mediterranean, and, according to Strabo, Greek geographer (c. 64 B.C.—A.D. 19), about 1200 B.C., they passed through the Straits of Gibraltar and founded cities in lands to the north and south. In the middle of the 9th century B.C. they founded Carthage, their greatest colony.

The Phoenicians had a natural bent for the sea, discovery, and trade; and they were persevering, enterprising, and industrious. Good shipbuilders, they constructed sturdy cargo vessels capable of carrying large quantities of merchandise. Courageous and wise, they fearlessly dared unknown waters and regions, and carefully guarded the secrets of trade routes they discovered. Their knowledge of winds, currents, and other data necessary for safe navigation, they kept to themselves. Strabo refers to the number and size of Phoenicia's colonial cities as evidence of her power in maritime affairs, and tells us that the Phoenicians were "philosophers in sciences of astronomy and arithmetic, having begun their studies with practical calculations and with night-sailings." It is said of them that they were the first to face the dangers of the open sea, the first to sail by the Pole Star, and the first to bring to the Middle East news of the remoter regions of Asia, Africa, and Europe.

Their skill in navigation and their reputation for daring and fortitude brought them into the service of many great rulers of the ancient world, including Solomon, Sennacherib, Necho, Xerxes, and Alexander the Great. Let us look for a moment at some of their famed voyages.

About 1000 B.C., King Solomon of Israel entered into a maritime commercial alliance with the Phoenician king, Hiram. At Ezion-geber, then a port in the Gulf of Akabah at the head of the Red Sea, Solomon built a fleet of ships, and Hiram sent "shipmen that had knowledge of the sea" to man them in company with the Israelites. It is not likely that many of the Israelites had experience as seamen, and we may be sure that the command and navigation of the ships were entrusted entirely to the Phoenicians. The fleet sailed and "came to Ophir, and fetched from thence gold." Nobody seems to know where Ophir was situated; it has been placed in Arabia, Africa, and India. Authorities are not in agreement on the part of the world to which the ships went, or the length of the voyage or voyages. It is not improbable that they were engaged in trade with India, from where they brought back rich cargoes of merchandise including spices. This may well have been the case, for Solomon "exceeded all the kings of the earth for riches," and it is abundantly clear from Biblical history that he counted spices amongst his treasures. The account is a testimony to the trading abilities and the maritime skill and knowledge of the Phoenicians.

From Herodotus, we learn of another great maritime feat of the Phoenicians. It was first proved, he says, that Africa was surrounded by water, except where it is attached to Asia, when Phoenician sailors circumnavigated the country in the time of Necho, king of Egypt (610—594 B.C.). It happened after Necho had ceased work on his canal.

The idea of a waterway that would link up the Mediterranean with the Red Sea occurred to men centuries before the plans of the French engineer, Ferdinand de Lesseps, led to the construction of the Suez Canal. A thousand years before Necho, the five vessels of Hatshepsut, bound for the land of Punt, sailed down the Nile and through a Middle Kingdom canal leading from the eastern delta through the Wadi Tumilat to Great Bitter Lake, which, at that time was still part of the Gulf of Suez. With the passage of time, sand deposits completely separated the Great Bitter Lake from the Gulf of Suez, and it seems that it was through this area that Necho attempted the construction of a canal. It was his intention to make it wide enough to permit two galleys, each fitted with three rows of oars on either side, to pass along it abreast. It must have been a very cruel task, for Herodotus tells us that 120,000 Egyptians lost their lives "in the digging of it." The canal was not completed by Necho, but by the Persian king, Darius (520—486 B.C.). Necho gave up because of an oracle which warned that "he was laboring for the barbarians." Herodotus explains that the Egyptians called all people barbarians who spoke a language, different from their own.

Necho knew that the waters of the Atlantic and the Mediterranean washed the shores of Africa, and since he was unable to complete his canal, he conceived the idea of sailing round Africa to carry out his plans. Having no knowledge of the real size of Africa, he doubtless thought that this could be accomplished in a short voyage. For this momentous undertaking, he did not employ Egyptian sailors to man his ships, but Phoenician.

Necho instructed the Phoenicians to keep the coast of Africa on their right, and to return to Egypt by way of the Straits of Gibraltar and the Mediterranean. The daring Phoenicians sailed down the Red Sea and through the

Gulf of Aden into the Indian Ocean, following the coastline of Africa and sailing as close to the shore as safe navigation would permit. Slowly but surely, they made their way south, and eventually rounded the Cape of Good Hope—over 2000 years before Portugal's Bartholomew Diaz was honored with its discovery! Then they sailed slowly north, until they came at last to the "Pillars of Heracles" and the Mediterranean, reaching Egypt in the third year of their famous voyage. We know nothing of their experiences, but we are sure that the difficulties of such an arduous undertaking were many, calling for skill, courage, and resourcefulness of a very high order. Food and water were among their major problems. Herodotus tells us that whenever autumn came, they put in at some suitable spot, sowed the land, awaited the harvest, gathered the crops, and then sailed on. While awaiting the harvest, it is certain that they used their time diligently in fishing, hunting, and gathering medicinal herbs.

We have seen that Strabo credited the Phoenicians with sailing out of the Mediterranean about 1200 B.C. Such a voyage was probably made time and time again, but the next recorded instance is that of Hanno. About 520 or 500 B.C., this famed Phoenician navigator sailed out of Carthage in command of a fleet of sixty big ships, on an expedition to explore and colonize the west coast of Africa. He led his ships through the Straits of Gibraltar, sailed south along the African coast, and reached a point somewhere beyond Sierra Leone, perhaps Cape Palmas. Several landings were made, and a colony started somewhere on the coast of Rio de Oro. On his return to Carthage, Hanno wrote an account of the voyage. A Greek translation, known as the *Periplus of Hanno*, still exists. Of such stuff were the Phoenicians made!

Now let us turn to the Arabians. The Arabians have been always of two types: mostly nomadic in the north, and mostly settled in the south. In early times, the wandering Arabs of the north herded their camels from pasture to pasture, stoically endured untold hardships, extracted what they needed from others by fair means or foul, ate simply, carried their fresh water in camel skins, and slept under tents of hair. They were essentially a land people, and we need not consider them further.

The settled Arabs of the coastal regions of the south existed very largely on the ancient trade in frankincense, myrrh, and other fragrant gums and resins. They obtained these aromatics from the southwest corner of Arabia and from the neighboring coastal region of Africa. Strabo tells us that the Sabaeans crossed the water to the African region, which he calls Ethiopia, in "leathern boats" to get the aromatics of that land and this was the practice of the inhabitants of southwest Arabia from earliest times. The south coast region, Hadramaut, was a source of frankincense, to where the Arabians of the west and east coasts came for supplies of this fragrant gum resin. And this territory must have been the trade link between the Arabians of the southwest district and those of the Persian Gulf region. From the shores of the Red Sea to those of the Persian Gulf, an aromatic trade was carried on from very remote ages, the Arabians of the Red Sea area trading with the Egyptians and those of the Persian Gulf area, with the Babylonians and Assyrians. This must be the foundation of the maritime history of Arabia. The southwest Arabians had seen the ships of Egypt come to their shores for aromatics, and this must have been all the example they needed to get them started in a water trade of their own. The Persian Gulf had known the presence of ships since the days of the Sumerians, and the Arabians of this area must have early freighted their aromatics by water to the head of the Gulf and then transported them inland over the Tigris and Euphrates rivers, which at that period still emptied separately into the Persian Gulf.

The southwest corner of Arabia, known to ancient authors as Arabia Felix, seems to have been always the most progressive part of the peninsula. According to Arab tradition, it was the scene of a great and powerful civilization in very early times. Here the Minaean kingdom was established about 1300 B.C. and flourished until about 650 B.C. And here the Sabaeans, the most accomplished of all ancient Arabians, founded their kingdom about 950 B.C. The Sabaeans lasted until about 115 B.C. and were followed by the Himyarites, who inherited the Minaean-Sabaean culture and trade. The Himyarites flourished until about A.D. 300. These three peoples were all identified with the spice trade, but the Sabaeans were the greatest spice merchants of them all. We shall read more about them in our next chapter.

Through the ancient trade in aromatics, the culture of other lands filtered into southwest Arabia, and her civilization was built on the riches of the spice trade. From here went the great abundance of spices to King Solomon, the tribute in spices to the Assyrian king, Sargon II, and the thousnd talents of frankincense yearly to the Persians in the time of Darius.

The first long voyages to the East were probably undertaken by the Arabians of Oman and the Persian Gulf area, where seaborne traffic had undoubtedly been known from remotest times. From Southwest Arabia went the great ships of the Sabaeans, and probably the earlier Minaeans, to India for the spices of that land. Arabia became the highway of trade between India and the Eastern Mediterranean, and many long voyages started from her coasts in ancient days; voyages which were probably every bit as famous as those of the Phoenicians. Unfortunately, practically nothing of their history is known. But for seamanship and skill in navigation, daring and fortitude, Arabian sailors must have been equal to Phoenician. Their later history as pioneers of sea lanes to distant parts of the world marks them as a people of the sea—keen, competent, and bold.

From these accounts it is clear that either Phoenicians or Arabians could have founded the trade with the East which brought the first cassia and cinnamon to the Middle East. Let us briefly sum up and see which people is more likely to have done so.

The Phoenicians were traders and sailors from the beginning of their history on the Syrian coast, and it is a reasonable conclusion that they were traders and sailors on the waters of the Persian Gulf before they migrated to the Syrian coast. But nothing is known of their history while they lived on the shores of the Persian Gulf, and we can neither affirm nor deny that they made long coastal voyages in those early days. If the early Phoenicians sailed from the Persian Gulf on coastal voyages to the East and returned with cassia and cinnamon, history knows nothing of it. No records so far unearthed speak of the presence of cassia and cinnamon in the Middle East in those remote ages.

By the time that cassia and cinnamon came into Middle East history, the Phoenicians were settled in their new homeland, busily occupied in building up a great maritime trade in the Mediterranean. It is most unlikely that they made voyages to the Far East at a time when their ships were needed to carry the merchandise of Western Asia to Greece, Italy, Spain, and North Africa.

The Phoenicians were dealers in every kind of merchandise; they carried and bartered the goods of all peoples. Spices were only a very small part of the mass of merchandise which passed through their hands; trade of any and every kind was their specialty. Their own products were Tyrian purple, fabrics, glassware and objects of precious metals; they produced no aromatics.

Ezekiel 27 eulogizes the riches and commerce of Tyre when that city was at the height of her prosperity (about the 6th century before Christ), and says that cassia was in her market. But the same chapter notes that Arabian merchants traded in Tyre with "chief of all spices," which might show that they carried cassia and cinnamon into Tyre to trade for the products of Phoenicia.

Herodotus says that the Greeks took the word *cinnamon* from the Phoenicians. Because it is held by some that this is a word almost certainly borrowed from the farther East, this statement might be claimed as evidence that the Phoenicians did indeed first bring cinnamon, and the word for it, from some Eastern land. But this does not necessarily follow. The explanation is probably that the Phoenicians, as early Mediterranean traders, were the first to carry cinnamon to Greece, and their word for this spice passed into the Greek language at that time. It should be observed that Herodotus, beyond his statement, certainly did not associate cinnamon (or cassia) with the Phoenicians, but with the Arabians.

In short: The Phoenicians were indeed notable manufacturers and great traders, but they produced no aromatics of their own and dealt in spices only as they dealt in every other kind of merchandise moving between East and West. They were renowned sailors and undoubtedly made long voyages to eastern parts of the world in later centuries, but nowhere in their maritime history are they mentioned as importers of cassia and cinnamon. Fundamentally, the Phoenicians were not spice merchants, but general merchants.

The South Arabians traded in aromatics from earliest times; other merchandise they also handled, of course, but spice trading was their mainstay. They were sagacious merchants, and long acquainted with sea trade.

It was to Southwest Arabia and the neighboring coastal land of Africa that Egyptians came for aromatics some 4,500 years ago; it was Arabian merchants who carried spicery from Gilead to Egypt some 3,666 years ago, and it was from Arabia that the ships of Hatshepsut sailed with cinnamon to Egypt some 3,500 years ago.

The South Arabians depended on the aromatic trade almost entirely for a livelihood. They traded their fragrant gums and resins in the Red Sea and in the Persian Gulf, and it is to be expected that they ventured on voyages of exploration in search of new spices to meet the growing demand in the Middle East for aromatics. We cannot point to them having made long coastal voyages to the East in very early times anymore than we could to the Phoenicians, but we can clearly see why they, rather than the Phoenicians, should have made such voyages. The cinnamon which was employed by the Egyptian queen, Hatshepsut, in 1500 B.C. and the cassia and cinnamon which the Israelites used in the rites of the tabernacle in 1490 B.C., all had to come from spice lands farther east, and it is only reasonable to conclude that these fragrant barks came into the Middle East by way of a spice-dealing people and no people in all the Middle East excelled the Arabians as spice merchants.

The whole coastal region of Arabia from the Persian Gulf through Hadramaut to the Red Sea knew the traffic of the Arabian spice merchants. From her most ancient people, through the Minaeans and Sabaeans to the Himyarites, the aromatic trade of South Arabia endured. The Sabaeans sent their ships overseas for spices and, for centuries, these people successfully monopolized the trade in cassia and cinnamon between eastern spice lands and the Middle East. They cleverly concealed the true source of cassia and cinnamon, and traded these fragrant spice barks to great advantage in all the markets of the Middle East.

In conclusion: Spices were indivisible from the lives of the South Arabians; they were their heritage and their mainstay. South Arabians were traders and sailors from earliest times and, by necessity, must have sought new sources of spices to meet the great demand of Middle East peoples. Cinnamon was early associated with their name and cassia and cinnamon were imported and distributed exclusively by them for centuries. There can be no doubt that they were the founders of the trade with Eastern spice lands which brought the first cassia and cinnamon to the Middle East. Thus, the question is answered.

The discovery of the coastal route to the Eastern spice lands must have been accomplished only after numerous daring explorations starting from the Persian Gulf coast of Arabia. Each voyage eastward would provide new knowledge of winds, currents, and other useful data on which to base the next. These voyages must have taken months, perhaps years, but each must have been productive of gain outweighing the importance of the time they required.

Leaving the Persian Gulf, the Arabian traders probably pushed eastward along the coasts of what are now Iran and Baluchistan, sailed past the mouth of the Indus, and then worked their way southward along the Indian coast until they reached Malabar ports.

Along the east coast of India, the coasts of Burma, Malay Peninsula, and Cochin-China, civilization was not undeveloped in those ages, and it is certain that some neighbor-to-neighbor trade was carried on. The bolder merchants must have ventured on short coastal trips to barter with one another, and it was possible in this way for the products of the Far East to make their way to Southern India or Ceylon. Trade in those remote times probably did not yield large quantities and varieties of merchandise, but only lots and kinds which could be passed easily from trader to trader and transported safely in their small craft. Of such merchandise, the highly desirable cassia must have been a chief part.

Ceylon was a noted meeting place for merchants in ancient days. Megasthenes, ambassador of Seleucus, who visited India 317—312 B.C., was among the first to speak of the commerce of this island, but trade had been carried on there long before his time. Ceylon boasts of a historical record of events of great antiquity, and existing ruins on the island point to a high civilization at a very remote period. Her original inhabitants are thought to have been related to an early people of the Malay Peninsula, which leaves it open for us to surmise a very early connection between the two places.

And so, through a chain of traders, the cassia of Cochin-China probably made its way to Southern India, or the island of Ceylon, from where it was conveyed, together with the Malabar cinnamon, in Arabian vessels to the Persian Gulf. Some cassia and cinnamon must have been landed at Oman and from there transported by camel train to Arabia Felix for the trade with Egyptians and Hebrews and some was carried to the head of the Gulf for transportation into Babylonia and Assyria by way of the Tigris and Euphrates rivers.

IV. THE ARABIAN SPICE TRADE

SOUTH Arabia became the great spice emporium of the ancient world, and South Arabians, the clever, mystifying masters of a very lucrative trade in domestic and imported spices. It was not their intention to let outsiders learn too much about their activities and to hide their trade secrets they invented and spread some very fantastic tales, particularly in regard to the origin and production of the highly desirable and costly spice barks, cassia and cinnamon. For the nature of these stories, and some other interesting information on the Arabian spice trade, let us turn to those notable writers of antiquity—Herodotus, Theophrastus, Strabo, and Pliny.

Herodotus lived in the 5th century before Christ and spent many years of his life traveling through the lands of the Middle East. His work, known as *The History of Herodotus*, gives much information about the products, arts, commerce, people, customs and traditions of the countries he visited and covers at length the subject of the Persian war against Greece. Just now, we are interested in his discussion of the natural products of Arabia.

In book III, Herodotus tells us that Arabia is the "only country" which produces cassia and cinnamon. These spices, he says, the Arabians do not get without trouble:

> Their manner of collecting the cassia is the following: They cover all their body and their face with the hides of oxen and other skins, leaving only holes for the eyes, and thus protected go in search of the cassia, which grows in a lake of no great depth. All round the shores and in the lake itself there dwell a number of winged animals, much resembling bats, which screech horribly, and are very valiant. These creatures they must keep from their eyes all the while that they gather the cassia.
>
> Still more wonderful is the mode in which they collect the cinnamon. Where the wood grows, and what country produces it, they cannot tell—only some, following probability, relate that it comes from the country in which Bacchus was brought up. Great birds, they say, bring the sticks which we Greeks, taking the word from the Phoenicians, call cinnamon, and carry them up into the air to make their nests. These are fastened with a sort of mud to a sheer face of rock, where no foot of man is able to climb. So the Arabians, to get the cinnamon, use the following artifice.

> They cut all the oxen and asses and beasts of burthen that die in their land into large pieces, which they carry with them into those regions,and place near the nests: then they withdraw to a distance, and the old birds, swooping down, seize the pieces of meat and fly with them up to their nests; which not being able to support the weight, break off and fall to the ground. Hereupon the Arabians return and collect the cinnamon, which is afterwards carried from Arabia into other countries.

The Arabians have always had a reputation for wisdom, and it seems that they were not lacking in cunning. In a day when people believed in witchcraft, visions, omens, oracles, charms and magic, such stories as these are freely accepted. Not only do they keep away the meddlesome and curious, but the value of these spices is greatly enhanced by the supposed dangers and difficulties which the Arabian spice merchants faced. It is difficult to believe that one so travelled and informed as Herodotus would have accepted such reports, but apparently he did.

Herodotus does not name the great birds he mentions in his cinnamon tale, but Pliny, when referring to Herodotus and his cinnamon story, names the Phoenix bird. In book II, Herodotus gives an account of this fabulous bird of Egyptian mythology:

> They have also another sacred bird called the phoenix, which I myself have never seen, except in pictures. Indeed it is a great rarity, even in Egypt, only coming there... once in five hundred years, when the old phoenix dies. Its size and appearance, if it is like the pictures, are as follows:—The plumage is partly red, partly golden, while the general make and size are almost exactly that of the eagle. They tell a story of what this bird does, which does not seem to me to be credible: that he comes all the way from Arabia, and brings the parent bird, all plastered over with myrrh, to the temple of the Sun, and there buries the body. In order to bring him, they say, he first forms a ball of myrrh as big as he finds he can carry: then he hollows out the ball, and puts his parent inside, after which he covers over the opening with fresh myrrh, and the ball is then of exactly the same weight as at first; so he brings it to Egypt, plastered over as I have said, and deposits it in the temple of the Sun.

This version persisted for ages with slight variations; it appears again in *The Annals*, written by the Roman historian, Tacitus, five centuries after Herodotus. Another version held that the phoenix lived for 500 years, was then consumed by fire in a nest of spices which it had built in Arabia, and then rose from its own ashes with renewed youth and beauty and lived on for another 500 years, and so on.

The stories which Herodotus relates about cassia and cinnamon were, of course, invented by the Arabians to hide the true source of these spices. Those who believed that cinnamon came from the country in which Bacchus was brought up, were, as Herodotus says, following a probability founded on the fact that, for ages, the Arabian spice merchants had obtained additional supplies of aromatic substances from the neighboring land of Africa. That they believed this particular part of Africa to be the ountry in which the mythical god of wine was brought up, is proved by the statement of Herodotus in book II:

> But Bacchus, according to the Greek tradition, was no sooner born than he was sewn up in Jupiter's thigh, and carried off to Nysa, above Egypt, in Ethiopia.

Ethiopia, we shall see later, became known as the "cinnamon-producing country." It was doubtless all right with the Arabians if others wanted to believe this, and as for Herodotus, he, apparently, was not interested in checking up on the Arabians, and closed the subject with these words:

> Concerning the spices of Arabia let no more be said. The whole country is scented with them, and exhales an odor marvellously sweet.

Over a hundred years later, came Theophrastus. He was an authority on plants, and is regarded by some as the founder of the science of botany. In book ix of his *Enquiry into Plants*, Theophrastus discusses cassia and cinnamon. His account of the production of these spices is not less fanciful than that given by Herodotus. Of cassia, he says:

> When they cut off the branches, they chop them up into lengths of about two fingers breadth or rather more, and these they sew up in raw hide; and then from the leather and the decaying wood little worms are engendered, which devour the wood but do not touch the bark, because it is bitter and has a pungent odor.

If the learned Theophrastus believed this, he certainly did not believe the tale he passes on about cinnamon:

> They say that it grows in deep glens and that in these there are numerous snakes which have a deadly bite; against these they protect their hands and feet before they go down into the glens, and then, when they have brought up the cinnamon, they divide it into three parts, and draw lots for it with the sun; and whatever portion falls to the lot of the sun they leave behind; and they say that, as soon as they leave the spot, they see this take fire. Now this is sheer fable.

It would seem that in the course of a century or so, the Arabians had changed their story a bit. In the account of Herodotus, you will fremember, it was the cassia, and not the cinnamon, which grew down in the shallows amongst hideous animals.

Theophrastus could not tell us more than others said, because it was impossible for him to investigate the nature and origin of spices which came from countries far removed from his homeland. But he was not accepting the current Arabian propaganda in its entirety. And he knew more about the origin of these spices than he could prove, for although he says that cassia and cinnamon "are found in the Arabian peninsula," he also makes this significant statement:

> As to all the other fragrant plants used for aromatic odors, they come partly from India whence they are sent over sea, and partly from Arabia, for instance...cinnamon and cassia.

From this it is quite clear that Theophrastus knew something of the trade in these spices between India and Arabia.

Three hundred years after Theophrastus, came Strabo the Greek geographer. He was born in the 1st century B.C. at Amasia in Pontus, Greece. He traveled throughout Egypt, Asia Minor, Greece and Italy, and spent several years in Rome. His *Geography* contains many interesting accounts of the lands of the Middle East, including Arabia.

Strabo colorfully introduces the subject of spices in Arabia, saying:

> That part of Arabia that produces the spices is small; and it is from this small territory, that the country got the name of "blest," because such merchandise is rare in our part of the world and costly.

He tells us that in his day the Arabs carried on an extensive and abundant trade in spices; that Arabian spice merchants were rich and that even a camel-driver "might attain to some sort of wealth" by trading in spices.

Speaking of the Sabaeans of Southwest Arabia, he says they produce in their "very fertile country" myrrh, frankincense and cinnamon, and such is the wealth of aromatics that the people are "lazy and easy going." The aromatics are in such abundance, says Strabo, that they use cassia and cinnamon instead of sticks and firewood.

> Those who live close to one another receive in continuous succession the loads of aromatics and deliver them to their next neighbors, as far as Syria and Mesopotamia; and when they are made drowsy by the sweet odors they overcome the drowsiness by inhaling the incense of asphalt and goat's beard.

The goat's beard, it should be explained, had a fragrant substance clinging to it called Labdanum or Ladanum, picked up when the goat browsed on the leaves of a certain small evergreen shrub growing in those parts. Strabo does not enlarge on the matter, but Herodotus mentions this substance in book III of his *History:*

> Ledanum, which the Arabs call *ladanum*, is procured in a yet stranger fashion. Found in a most inodorous place, it is the sweetest-scented of all substances. It is gathered

> from the beards of he-goats, where it is found sticking like gum, having come from the bushes on which they browse. It is used in many sorts of unguents, and is what the Arabs burn chiefly as incense.

Speaking of the Gerrhaeans, who dwelt along the Persian Gulf coast of Arabia, Strabo says they traffic by land, for the most part, in aromatics, "though Aristobulus says on the contrary, that the Gerrhaeans import most of their cargoes on rafts to Babylonia, and thence sail up the Euphrates with them, and they convey them by land to all parts of the country." This was one of the routes used by the Arabians to distribute their spics in the Middle East. Other routes led from Gerrha by land northwest to Babylonia, Bostra, and to Petra, and south to Hadhramaut. On the Red Sea coast of Arabia, a route led from Hadhramaut to Mecca, and on to Elath, Petra and Gaza. From Petra, a route crossed the Sinai peninsula into Egypt.

Strabo tells us that the Sabaeans and Gerrhaeans became the richest of all the tribes of Arabia through their great trade in spices. They lived in costly and magnificent houses, with doors, walls and roofs variegated with inlaid ivory, gold, silver, and precious stones, and furnished with a great quantity of wrought articles in gold and silver.

No doubt all these conditions obtained in Strabo's day, but it should be observed that he got his information from Artemidorus, a geographer who lived about 100 B.C., and Artemidorus, it seems, got it from Agatharchides of Cnidus, a Greek historian and geographer, who lived in the time of Ptolemy Philometer (181—146 B.C.). Agatharchides was president of the famed Alexandrian library, where Strabo probably got much of his material.

Speaking of the country of the Sabaeans, Agatharchides says in part, "its very air is so perfumed with odors, that the natives are obliged to mitigate the fragrance by scents that have an opposite tendency,." Although he was aware that the Sabaeans sailed in very large vessels "to the country where the odoriferous commodities are produced," he knew nothing of their import traffic in cassia and cinnamon, but believed that these spices were produced in Arabia from "trees of extraordinary magnitude."

Nor did Strabo seem to know the true source of these spices. His reference to the production of cassia is not very clear:

> They say that...cassia is produced also from marshes. Some say that most of the latter comes from India.

It would appear from this that the old stories about cassia growing in shallow lakes, or glens, were still in circulation. And it is evident that there were people in Strabo's day who believed, as had Theophrastus 300 years earlier, that some of this spice came from India.

Cinnamon, he says, grows in Arabia, and also in Ethiopia. He refers many times to Ethiopia as "the cinnamon-producing country." And he quotes Aristobulus (c. 160 B.C.) as saying that "the southern land of India, like Arabia and Ethiopia, bears cinnamon." Strabo says that in his day, merchants were reaching the Ganges, which meant that they had to sail south of Cape Comorin and Ceylon, where they would be certain to land, yet, they seem not to have discovered the real source of Arabian cinnamon, nor found the spice themselves. Had they done so, Strabo would surely have known it. Skilful Arabians! Men informed enough to know, or at least suspect, that cinnamon was a product of Southern India, were not informed enough to know that it didn't grow in Arabia, or Ethiopia, so carefully did the Arabian spice merchants guard their affairs both in Arabia and India.

It is easy to understand why some should have thought in the 5th century before Christ that Ethiopia was the natural home of cinnamon, but difficult to account for the reputation of this African land as a "cinnamon-producing" country in Strabo's day. It is not improbable that when the Sabaeans came to take advantage of the monsoons, the winds brought their ships up on the Ethiopian coast where they found it practicable and expedient to land their cassia and cinnamon. The subsequent carriage of these spices to Arabia would then, doubtless, give rise to the popular idea that cassia and cinnamon grew in Ethiopia.

And now we come to Pliny the Elder, our final authority on the Arabian spice trade. This Latin author was born in A.D. 23, and lost his life when Mt. Vesuvius erupted and destroyed the city of Pompeii in A.D. 79. His celebrated *Natural History* contains a wealth of information on a wide range of subjects, including the description and uses of numerous plants.

Pliny gives us no glowing report of the Arabian spice trade as Strabo has done, and insofar as Arabia's claim to cassia and cinnamon is concerned, he rushes in to attack: "Arabia produces neither cinnamon nor cassia, and this is styled 'Happy' Arabia!" And then he blasts their stories to pieces:

> Fabulous antiquity, and Herodotus more particularly have related that cinnamon and cassia are found in the nests of certain birds, and principally that of the phoenix, in the districts where Father Libe was brought up; and that these substances either fall from the inaccessibe rocks and trees in which the nests are built, in consequence of the weight of the pieces of flesh which the birds carry up, or else are brought down by the aid of arrows loaded with lead. It is said, also, that cassia grows around certain marshes, but is protected by a frightful kind of bat armed with claws, and by winged serpents as well. All these tales, however, have been evidently invented for the purpose of enhancing the prices of these commodities. Another story, too, bears them company, to the effect that under the rays of the noon-day sun, the entire peninsula exhales a certain indescribable perfume composed of its numerous odors, and, indeed, were the first to announce the vicinity of Arabia to the fleets of Alexander the Great,

> while still far out to sea. All this, however, is false.*

So the cat is out of the bag! Pliny is wise to the wily Arabian spice merchants, and knows that they have been bluffing all along; they don't produce cassia and cinnamon in their country, and for centuries they have told these ridiculous stories just to keep up the prices of these barks. And another thing, Arabia isn't a sweet-smelling place after all. It is all false, he says. Well, we cannot disagree with Pliny. We have no doubt about the immensity and wealth of the spice trade carried on by the Arabians, but that they contrived by all the subtle means at their command to maintain a highly profitable monopoly of the trade in cassia and cinnamon, is all too obvious. But does he know where these spices come from? We shall see. "Cinnamon," he says, "grows in the country of the Ethiopians...cassia grows not far from the plains where cinnamon is produced." So we are back to the land of Bacchus, and Strabo's Ethiopia! Very disappointing!

In Ethiopia, Pliny says, the cinnamon is only gathered with the consent of the god Assabinus, who permits the collection of the spice only between the hours of sunrise and sunset, and who must first receive from the gatherers an offering consisting of the entrails of forty-four oxen, goats, and rams. After the cinnamon is collected, a priest divides the shoots with a spear "and sets aside a portion of them for the god; after which the dealer stores away the rest in lumps." Probably quoting Theophrastus, he adds:

> There is another account given, which states that a division is made between the gatherers and the sun, and that it is divided into three portions, after which lots are twice drawn, and the share which falls to the sun is left there, and forthright ignites spontaneously.*

The process which Pliny describes for the preparation of the cassia bark is similar to that explained by Theophrastus. He says:

> They cut the ends of the branches to the length of two fingers, and then sew them in the fresh skins of cattle that have been killed expressly for the purpose; the object being that the skins may putrefy, and the maggots engendered thereby may eat away the woody parts, and so excavate the bark, which is so intensely bitter, that it is quite safe from their attacks.*

Describing the export of these spices from Ethiopia, he tells us that they are carried over vast tracts of sea, on rafts, which are neither steered by rudder, nor drawn or impelled by oars or sails. He continues:

> Nor yet are they aided by any of the resources of art, man alone, and his daring

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* Book XII.

> boldness, standing in place of all these; in addition to which, they choose the winter season, about the time of the equinox, for their voyage, for then a south easterly wind is blowing; these winds guide them in a straight course from gulf to gulf, and after they have doubled the promontory of Arabia, the north east wind carries them to a port of the Gebanitae, known by the name of Ocilia. Hence it is that they steer for this port in preference; and they say that it is almost five years before the merchants are able to effect their return, while many perish on the voyage.*

It is difficult to consider these accounts any less fabulous than those of Herodotus. Pliny scorned Herodotus, but he was obviously a very credulous person himself. He wasn't so wise to the Arabians after all! When he said that cassia and cinnamon are not the products of Arabia, he was right. He evidently knew that these spices had to come into Arabia from the outside, but when he said that they grew in Ethiopia he was all wrong. Either he had heard Ethiopia spoken of as a cinnamon country, or he had taken the word from Strabo, if not from Herodotus himself.

We have already given a reason which might account for Ethiopia's reputation as a cinnamon-producing country. To this, we might add the probability that the Arabians found in Ethiopia a species of aromatic bark suitable for compounding or adulterating purposes. That adulteration was practiced in those days can be gathered from Pliny, who tells us that a variety of cassia, which he calls isocinnamon, was adulterated with storax and small sprigs of laurel. When gathering such a bark, the Arabians would say that they were gathering cinnamon.

It is a testimony to the sagacity of the Arabian spice merchants that more was not known about their overseas trading activities in the days of Strabo and Pliny. Both these writers discussed India, and both were aware of trade with India in their day. In book II, Strabo speaks of the traffic of the Alexandrian merchants, whose ships passed along the Red Sea to India. He also tells us that when he accompanied his friend Aelius Gallus, a Roman commander, to Syene and the frontiers of Ethiopia, he found that about 120 ships regularly sailed from the Red Sea port of Myos-Hormos to India, "although, in the time of the Ptolemies, scarcely any one would venture on this voyage and the commerce of the Indies." It is likely that these ships were engaged in the pepper trade, a trade which apparently the Arabians did not touch.

Pliny also mentions ginger and cardamom as products of Arabia, and apparently he had heard that some cardamom grew in India, but actually he had no more idea of the true origin of these spices than he had of cassia and cinnamon. We can be sure that the Arabians imported ginger and cardamom together with cassia and cinnamon, and that all these spices were part of their great and wisely protected trade in overseas aromatics. Considering the nature of all four products, it is understandable why they traded in them to the probable exclusion of pepper, which they left to others. Pepper had little to recommend itself to the people of those days, if we judge by the disparaging remarks of Pliny which we shall read later, whereas the others had a desirable fragrance particularly suited to the nature and customs of the people of the Middle East.

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* Book XII.

Pliny contemptuously dismissed Arabia as the land of spices, but, nevertheless, Arabia was, in his day and had been for centuries before him, the spice emporium of the ancient world. Its trade was immense, lucrative, and well organized. The Arabs were astute and competent, and the hold they had gained on the spice trade before the days of Herodotus, they maintained long after the days of Pliny. "Happy Arabia" is not so easy to dismiss!

V. USES OF SPICES IN THE ANCIENT GREEK AND ROMAN WORLD

IN war and peace, palace and hovel, temple and arena, fact and fable, the spices had their part in the lives of the people of the ancient Greek and Roman world. In preparation for the passage of the Persian armies, soldiers burned all kinds of spices on the bridges built by Xerxes across the Hellespont, during his war against the Greeks in the 5th century before Christ. The soldiers of Alexander the Great, marching through Gedrosia from India, used spice plants for tent coverings and bedding. Laurel leaves decorated the weapons of Roman soldiers and adorned their fasces; and in them, Roman generals wrapped their dispatches. In the social life of the ancient Greeks and Romans, spices were the essence of personal luxury; and an important part of public functions, banquets and parties. Cardamom, cassia, cinnamon, and sweet marjoram were among the ingredients of their perfumes; and anise, basil, fennel leaves, coriander, and garlic were among their aphrodisiacs. Spice-scented oils to soothe the skin were a part of the routine of the bath, and used by athletes to anoint the body. Their wines were flavored with spices, and among their kitchen implements they had mortars and pestles in which to pound and powder the spices they used in cooking. Laurel leaves formed the wreaths with which the victors in the sacred games were crowned. Costly spices were among the most desirable of gifts, just as they had been in the days of Sheba and Solomon; cassia and cinnamon, for example, formed part of the royal gift presented by Seleucus I to the temple of Apollo at Miletus. Spices, and oils perfumed with spices, were placed in the temples for the acceptance of the gods. Spices were an important source of revenue for the royal coffers and in the time of the early Ptolemies their import was under royal control, as was also the manufacture of scented preparations from them, and the extraction of sesame oil. In medicine, the spices were used to heal the sick and the wounded; and they were employed lavishly in the funeral rites of prominent people.

Most of the spices used by the people of today were known to the ancient Greeks and Romans, and we are able to give you some information on how they were employed. Anise was used in the kitchen for the making of seasonings, relishes, and sauces and together with cumin in the making of a cake which was customarily eaten by the Romans at the end of a meal to prevent indigestion. They considered aniseed excellent for flavoring wine. It was used to sweeten the breath, promote the appetite, as an aphrodisiac, and also as a moth repellent. In Pliny's day, the most esteemed anise was that of Crete, with Egypt supplying the next best in quality. Sweet basil was probably used for culinary purposes in those days, but all we know for sure is that it was used as an aphrodisiac, "for which reason" says Pliny, "it is given to horses and asses at the season for covering." Caraway was principally employed for culinary purposes. Cumin found favor as a food seasoning and, with coriander, it was employed for preserving meat. Fennel was extensively employed in seasonings and to flavor sauces made with vinegar. The leaves of fennel found favor as an aphrodisiac. Garlic was a popular food and seasoning. According to Pliny, it was a dish of "high rank" to the rural population of Africa. Beaten up with coriander, and taken in pure white wine, it was also used as an aphrodisiac. Ginger was employed in the kitchen to flavor meat dishes and to season relishes and sauces. Mint was a favorite food seasoning, and was used to flavor meat sauces. It was added to milk to prevent its turning sour, and to keep it from curdling. Like aniseed, it was emploed to flavor wine. Peppermint sprays decorated the banquet tables, and both Greeks and Romans crowned themselves with it at their feasts. Mustard was a condiment, used, it would seem, in much the same way as we employ it today. Thyme was employed to flavor cheese and liquor. It was also used for fumigating.

Both black and white pepper were employed in the kitchens of the ancient Greeks and Romans. When pepper first came into use in those parts, we do not know, but Theophrastus spoke about two kinds of pepper some 400 years before the publication of Pliny's *Natural History*. Pliny distinguished between black and white pepper and observed that the black "is of a more agreeable flavor; but the white pepper is of a milder quality." He did not have a very high regard for this spice:

> It is quite surprising that the use of pepper has come so much into fashion, seeing that in other substances which we use, it is sometimes their sweetness and sometimes their appearance that has attracted our notice; whereas pepper has nothing in it that can plead as a recommendation to either fruit or berry, its only desirable quality being a certain pungency; and yet it is for this that we import it all the way from

> India! Who was the first to make trial of it as an article of food? and who, I wonder, was the man that was not content to prepare himself by hunger only the satisfying of a greedy appetite.*

Coupling ginger (for which he probably had as little respect) with pepper, he adds:

> Both pepper and ginger grow wild in their respective countries [Pliny attributed ginger to Arabia and Africa], and yet here we buy them by weight—just as if they were so much gold and silver.*

Pliny tells us that the price of white pepper was seven denarii per pound and that of black, four; this wold be about $ 1.25 and 70¢ respectively—very expensive pepper when we consider the purchasing power of such sums in Pliny's day.

In the realm of superstition, the ancients entertained some strange notions about some of the spices. Anise, they said, imparted a youthful look to the features; how this was accomplished we are not able to tell you. They believed that if anise was fastened to the pillow so that the fragrance of the spice might be inhaled by the sleeper, all disagreeable dreams would be prevented. Travellers who wished to be free from fatigue on a long journey were advised to add this spice to their drink.

In ancient Greece, sweet basil was the symbol of hatred, and in India it was worshipped as a sacred herb. It was believed in ancient Rome that if basil was pounded and left beneath a stone, a scorpion would breed in its midst; and if chewed and left in the sun, worms would breed in it. Some Romans said that a handful of basil pounded together with ten crabs would attract all scorpions in the vicinity. Africans believed that a person bitten by a scorpion on the same day as he or she had easten basil could not live.

Cumin, the ancients believed, if cursed and abused while sowing, would produce a splendid crop. The seeds of cumin were said to bring pallor to the face and produce the complexion of one constantly absorbed in serious study. The ancient Greeks considered this spice the symbol of avarice.

Fennel was believed to sharpen the sight of snakes and to aid them in casting off their skins in the spring. Pliny says:

> Fennel has been rendered famous by the serpent, which tastes it...and sharpens its sight wth the juice of this plant.**
>
> The snake, when the membrane which covers its body has been contracted by the cold of the winter, throws it off in the spring by the aid of the juices of fennel, and

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* Book XII.

** Book XX.

> thus becomes sleek and youthful in appearance.*

It was believed that garlic, if planted when the moon was below the horizon and gathered when the moon was nearest the earth, would be deprived of its strong smell. The offensive smell of garlic on the breath could be overcome, they said, if one ate the root of a beet which had been roasted on coals. To preserve the seeds in a newly sown field from the ravages of birds, the ancients were advised to boil the seeds of a certain variety of garlic to prevent their sprouting and then scatter them over the ground. Birds eating these seeds would become stupified and soon fall fast asleep and, in that condition, could be easily captured by the farmer. Modern farmers and backyard gardeners might take a tip from this!

Laurel, the ancients believed, communicated the spirit of prophecy and poetry, and those seeking inspiration were advised to put laurel leaves under their pillow.

Sweet marjoram was used by both Greeks and Romans to make the crowns worn by happy young couples. The Greeks believed it symbolized the happiness of the departed one if this fragrant herb grew on the grave. Mint they named after Minthe "who according to myth, became the concubine of Hades, was trampled underfoot by Core, and transformed into garden-mint" (Strabo). Parsley was believed capable of warding off intoxication and, for this reason, it was woven into wreaths and worn by Greeks and Romans at their banquets. Saffron, they said, loved abuse; Pliny wrote:

> It loves to be beaten and trodden underfoot, and in fact, the worse it is treated the better it thrives.

Some of us are like that, are we not? Thyme, they said, could not thrive unless grown within the range of the sea breezes. They believed it was from the flower of thyme that the bee got honey, and beekeepers of those days said that an abundance of thyme blossoms augured well for the honey yield.

Laurel leaves and parsley found a part in the ancient Greek games. In Greek mythology, Pythia was the maid who gave the responses of the oracle at Delphi. She first drank from the holy spring and then chewed laurel leaves before she uttered the god's decrees. Probably that is why laurel leaves were used to form the wreaths given to the victors in the Pythian games, celebrated every four years near Delphi in honor of Apollo. Parsley formed the wreaths awarded to the victors in the sacred contests of the Nemean games.

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* Book VIII.

Spices had a significant place in the funeral rites and customs of the ancients. Sweet marjoram was among the flowers used in the funeral wreaths of both Greeks and Romans. In Greece, parsley was strewn over the bodies of the dead, and planted on their graves; and Egyptians scattered this spice on the graves of their loved ones. Two stories in *The Annals* of Tacitus indicate the extent to which spices were used in the funeral ceremonies of exalted people. In the first, Tacitus tells of the funeral of the great Roman general Germanicus, of whom he says, "he had the bravery of Alexander without his rashness." Germanicus died under very suspicious circumstances while he was serving his country in Syria. His wife, Agrippina, brought his ashes home and deposited them in the tomb of Augustus in the Campus Martius of Rome. Describing the journey, Tacitus says in part:

> The urn was borne on the shoulders of the centurions and tribunes, preceded by the colours, not displayed with military pomp, but drooping in disorder, with all the negligence of grief. The fasces were inverted. In the colonies through which they passed, the populace in mourning and the knights, in their purple robes, threw into the flames rich perfumes, spices, and garments, with other funeral offerings, according to the ability of the place.

In the second, Tacitus tells of the death of Poppaea, wife of Nero:

> The public games were followed by the death of Poppaea. She died of a kick on her womb, which Nero gave her in a sudden passion, though she was then advanced in her pregnancy....
> Her body was not, according to the Roman custom, committed to the funeral pile, but after the manner of the eastern kings, embalmed with precious spices, and deposited in the monument of the Julian family.

Pliny, speaking of this funeral, commented on the profusion of cinnamon and other aromatics.

Now, let us consider some of the medicinal uses of spices in those days. Much of the medicine of the ancients was founded on the therapeutic power of plants and among these, the spices are quite prominent. Under its founder Alexander the Great and his successors the Ptolemies, the city of Alexandria was a celebrated seat of learning, and its famed medical school excelled all others in that period. Through three centuries, eminent herbalists contributed to the materia medica of the college; some of their information was the result of their own careful observations and experiments, and some came from their researches in Egyptian, Babylonian and Assyrian medicine of an ealier period. Unfortunately, many of the works of these ancient scholars do no longer exist, but, thanks to Hippocrates, Theophrastus, Dioscorides, and particularly to Pliny the Elder, we have a very comprehensive list of remedies which depended on the efficacy of the spices.

Hippocrates (c. 460—370 B.C.), Greek physician, was born at Cos, an island off the coast of Asia Minor. He first learned about medicine from his father and later, from Athenian teachers. He traveled and practised in Thrace, Thessaly and Macedonia, and wrote at length on the subject of medicine. His work in dissociating medicine from magic and elevating it to the dignity of a science brought lasting fame to his name. The Oath of Hippocrates, taken by all graduating physicians, is the guardian of the ethics of the profession. He is called "The Father of Medicine."

Hippocrates tells us that anise will stop sneezing; coriander will prevent heartburn, and promote sleep; thyme will expel phlegm; savory and marjoram will eliminate excess bile; and mint will stop vomiting. But mint, he warns, "if eaten often melts the seed and makes it run, preventing erections and weakening the body." Onion, he says, is good for the sight, and bad for the body; garlic is bad for the eyes, and good for the body.

Theophrastus emphasizes the astringent and drying properties of cassia and cinnamon, ingredients in a substance called *Megaleion*, which, he says, is "believed to relieve the inflammation of any wound."

Pliny treats the spice remedies at length and quotes many medical and herbal authorities. A full account might bore you a little, but we shall tell you of the more interesting cures. His prescriptions called for the use of different parts of the spice plant, in some cases, the spice as we know it and in others, the leaves and roots. They were used alone or in combination with other substances, for example, honey, polenta, wine, rose oil, asses' milk, vinegar, pitch, pomegranate juice, women's milk, and axle grease. Sometimes two or more spices were combined in the preparation of the medicines.

He recommends anise for the treatment of the eyes, cancer of the nose, quinsey, sneezing, calculi of the bladder, vomiting, chest affections, headache, dysentery, lumbago, dropsy, ague, and many other ills that man is heir to. Women who suffer from tight lacing will find anise beneficial, and those in labor will have an "easy delivery" if they inhale its odor. He says, anise dispels vertigo after child birth, and it promotes sleep. But "still, however, it is injurious to the stomach, except when suffering from flatulency." Pliny quotes Pythagoras as saying that those who hold anise in the hand will never be attacked by epilepsy, "for which reason, as much of it as possible should be planted near the house."

Sweet basil, continues Pliny, is a cure for the stings of land scorpions. Its smell in vinegar is good for fainting fits; and it is most efficacious in cases of jaundice, dropsy, cholera, and looseness of the bowels.

Coriander, he says, is beneficial in the treatment of wounds and blisters; and good for "dispersing" tumors and gatherings. It is excellent in treating spreading ulcers, diseases of the testes, burns, carbuncles, and maladies of the ears. "Applied with women's milk" it is good for the eyes. A potion made by compounding coriander seed, pomegranate juice and oil, is effective in expelling worms.

Dill overcomes stomach gripings and looseness of the bowels. Inhalation of the vapor from the water in which dill seeds are boiling will arrest hiccup. Dill seed taken in water will cure indigestion. But, Pliny warns, "the plant itself weakens the eyesight and the generative powers."

Fennel, he says, is most beneficial to the human sight: This, of course, came from the ancient belief that fennel sharpened the sight of the serpent. He esteems fennel in treating diseases of the lungs and liver; to allay nausea, and says it is good for tumors, bruises, bites of dogs, stings of scorpions, serpents and millipedes. "In whatever way it is taken in drink, fennel has the property of promoting the secretion of the seminal fluids; and it is extremely beneficial to the generative organs."

Fenugreek, he extols as a dessicative, emollient, and resolvent. It is useful in the treatment of many female maladies, and helpful in cases of difficult labor. He recommends the use of this spice in treating affections of the joints, and for diseases of the uterus and intestines. It removes ringworm and dandruff, and is "a corrective of the rank odors of the armpits." Used with axle-grease and hydromel, it is a cure for "diseases of the generative organs." It also cures sprains, tumors, gout, rheumatism, carcinomatous sores, and chronic coughs.

Garlic, says Pliny, has "very powerful properties,...the very smell of it drives away serpents and scorpions." It cures the wounds made by wild beasts, and is "a powerful remedy for the bite of the shrew-mouse." With pitch, it will "extract an arrow from the wound." He says, "the ancients used to give raw garlic in cases of madness, and Diocles administered it boiled for phrenitis." It is good for toothache if a small piece is placed in the cavity of the tooth, or if the mouth is washed with a decoction made by beating up three heads of garlic in vinegar. The list of cures attributed to garlic by Pliny is too long to repeat here, but among other diseases it is a remedy for tapeworm, leprosy, epilepsy, coughs and chest complaints. However, he warns that the use of garlic dims the sight and causes flatulency, "and if taken in too large quantities, it does injury to the stomach, and creates thirst." It also has its veterinary uses, and if given to poultry in their food, it will preserve them from "attacks of the pip."

Mint, he highly esteems: "The very smell of it reanimates the spirits."

If taken just before an oration, it is good for the voice. Inhaled, it is a remedy for the affections of the nostrils. Taken with pomegranate juice it will arrest hiccup and vomiting. It is an antidote for the stings of sea scorpions, and serpents. Mint will, he says, cure or alleviate abscesses of the uterus, diseases of the liver, spitting of blood, and other serious maladies. "If held in the hand only," it will prevent chafing of the skin. Mint will cure diseases of the spleen "if tasted in the garden nine days consecutively, without plucking it, the person who bites it saying at the same moment that he does so for the benefit of the spleen."

Mustard, Pliny tells us, was ranked by Pythagoras "among the very first of those plants the pungency of which mounts upward; for there is none to be found more penetrating to the brain and nostrils." It is, says Pliny, beneficial in cases of fits of lassitude and hysteria in females, and it resuscitates those who swoon from epilepsy or lethargy. He recommends its use in curing inveterate pains of the chest, loins, hips, shoulders, "and, in general, for all deep-seated pains in any part of the body, raising blisters by its caustic properties." Some of you will have had experience of the latter! He tells us to employ a double cloth "where it is apprehended that it may burn too powerfully." Used with figs and cumin, mustard is useful as an external application for dropsy; and with red-earth, it is beneficial for leprosy and tetanus. The ancients were familiar with mustard oil which they extracted from the seeds with pressure. Pliny mentions its employment for "rigidity of the sinews, and chills and numbness in the loins and hips."

Origanum, he says, is good for indigestion, and to alleviate "gnawing pains at the stomach." It is beneficial in the treatment of stings of spiders and scorpions, and as a remedy for sprains and bruises, bleeding at the nose, dropsy, ruptures, convulsions, affections of the tonsils, and toothache.

Rosemary is useful in the treatment of wounds, prolapsus of the rectum, piles, jaundice, diseases of the chest, gout, freckles, and coughs. Taken in wine, he says, it increases the milk of nursing mothers.

Saffron, he claims, is useful in cases of hysterical suffocation; and in ulcerations of the stomach, chest, kidneys, liver, lungs, and bladder.

Sesame is an antidote "to the bite of the spotted lizard." It arrests vomiting, and is "applied topically to inflammations of the ears, and burns." "As an aliment," Pliny says, "it is injurious to the stomach, and imparts a bad odor to the breath" (which is rather rough on a seed that found such favor in times of antiquity).

Dioscorides (c. A.D. 40—90), Greek physician, and a contemporary of Pliny the Elder, was a military surgeon in the Roman army under the emperor Nero. In this capacity, he traveled extensively and carefully observed the plants, animals, and minerals of the lands through which he passed. From his observations and inquiries, he compiled his celebrated *Materia Medica*. Among the spices mentioned in his great work are aniseed, caraway, cardamom, cumin, cinnamon, coriander, ginger, marjoram, mustard, pepper, peppermint, poppy, sesame and thyme. He also speaks of an Indian plant which yielded a yellow color when chewed, and which was bitter to the taste; this was no doubt the spice turmeric. Dioscorides says that oil of caraway, taken internally, is good for pale-faced girls.

Many of the fantastic claims, made for the medicinal virtues of the spices in those days, endured through the centuries to find their way into the leechbooks and herbals of the Middle Ages, and some have endured until this day.

VI. SPICES IN THE EARLY CHRISTIAN ERA AND MIDDLE AGES

IN the closing centuries of the pre-Christian era, sea trade between the Middle East and India began to increase rapidly. We have seen that the Arabians enjoyed for centuries a monopoly of the trade in Eastern spices which had not terminated by the time of Pliny. They were able to keep secret the true source of cassia and cinnamon, but it is not likely that they were able to keep secret the long voyages they were making to the East. Their trade expeditions must have been known to the international traders of Alexandria, even if the nature of their cargo was not. And it is certain that these merchants were watching them very carefully, and making plans to get into the Eastern trade themselves. These plans seem to have matured during the reign of Ptolemy Philadelphus (285—246 B.C.). The ancient canal which connected the Nile with the Red Sea was reopened, permitting entry to the Arabian Sea of Ptolemaic ships and those of the merchants of Alexandria, and trade between Egypt and India began. By the time of Strabo, as we have seen, there were regular sailings of large fleets of ships from the Red Sea. An important factor in the development of this trade was the discovery of the monosoons. We suspect that the Arabians had been taking advantage of these favorable winds for some time, but it appears from the account of Strabo that it was not until a shipwrecked Indian was found off the Gulf of Aden that the Egyptians discovered the monsoons. At that time, according to the story told by Strabo, who took it from Posidonius (c. 135—51 B.C.),

> A certain Eudoxus of Cyzicus, sent with sacrifices and oblations to the Corean games, travelled into Egypt in the reign of Euergetes II [Ptolemy VII, king of Egypt, styled Euergetes II; his reign commenced 170 B.C.]; and being a learned man, and much interested in the peculiarities of different countries, he made interest with the king and his ministers on the subject, but especially for exploring the Nile. It chanced that a certain Indian was brought to the king by the guard of the Arabian Gulf. They reported that they had found him in a ship, alone, and half dead: but that they neither knew who he was, nor where he came from, as he spoke a language they could not

> understand. He was placed in the hands of preceptors appointed to teach him the Greek language. On acquiring which, he related how he had started from the coasts of India, but lost his course, and reached Egypt alone, all his companions having perished from hunger; but that if he were restored to his country he would point out to those sent with him by the king, the route by sea to India. Eudoxus was of the number thus sent. He set sail with a good supply of presents, and brought back with him in exchange aromatics and precious stones...

The spice trade at that time was in the hands of the merchants of south Arabia, and doubtless Ptolemy VII, who would know all about the large profit in spices, saw an opportunity to discover a short route to India; you will note that Eudoxus brought back a cargo of *aromatics* and precious stones. Ptolemy, observing the royal prerogative, promptly took possession of the imported spices and stones, much to the annoyance of Eudoxus.

Eudoxus made a second voyage to India, and on his return trip, he was carried by the winds "above Ethiopia" and was himself shipwrecked. He finally made his way to the court of Ptolemy VIII, the then reigning prince, "but he was again stripped of everything on the accusation of having appropriated to his own uses a large portion of the merchandise sent out."

Strabo thought the story of Eudoxus and the shipwrecked Indian a lot of nonsense, and he critically examined it at some length. He was not at all satisfied that it was necessary to employ an Indian to pilot the ship on its eastern voyage, and asked this significant question:

> ...and how came it that Euergetes was in want of such guides, so many being already acquainted with the sea?

Credit for the discovery of the monsoons is usually given to a sailor named Hippalus who is thought to have made his voyage to India with the help of these winds sometime during the 1st century of our era. But the voyage of Eudoxus took place in 170 B.C. or shortly after that year. An important thing to note is the suggestion in Strabo's statement that there was nothing new in the achievement of Eudoxus; or, in other words, traders had been making their way to India with the help of the monsoons before Eudoxus made his voyage with the help of the Indian pilot. Theophrastus, writing between 370 and 287 B.C., said that some aromatic plants came from India "sent over sea." This might show that Strabo was not wrong, and that perhaps from the 4th century before Christ, the ocean had been crossed with the help of the monsoons by Arabians, or even Indians. It is possible that news of Arabian sailings across the open ocean had reached Ptolemy Philadelphus and spurred him to the task of reopening the canal and getting Egyptian ships into the Indian trade.

When the Romans conquered Egypt, about the middle of the 1st century before Christ, they carried on the sea trade started by the Ptolemies and as the Christian era approached, the Arabian monopoly of the overseas spice trade began to break up. But this is not to say that the Arabians ceased to trade in spices; on the contrary, despite the presence of the ships of Alexandrian merchants in eastern waters, they remained active and dominant spice traders until the ascendancy of the Portuguese in the 16th century.

The dawn of the Christian era found Egypt a Roman possession. Antony and Cleopatra had been defeated at the battle of Actium, both had committed suicide, and Caius Octavius, later styled Augustus, became master of that ancient land. Under the Ptolemies the city of Alexandria had risen in importance until it was second only to Rome. Alexandria was bequeathed to the Roman senate by Ptolemy Alexander in 80 B.C., and it was now the greatest trading port in the eastern Mediterranean for the merchants of Italy, Greece, and the Middle East. Memphis enjoyed a commercial importance not less than that of Cairo today and Coptus was a prominent trading city. Strabo tells us, "and now all the Indian merchandise, as well as the Arabian and such of the Ethiopian as is brought down by the Arabian Gulf, is carried to Coptus, which is the emporium for such cargoes."

During the first three centuries of the Christian era, trade between the Roman empire and the east, particularly India, became quite extensive, both by land and water. The spices of India made their way by the Red Sea to Coptus, Memphis, and Alexandria; and from Alexandria, they were distributed to Greece and Italy. The Arabians were actively engaged in this spice trade and cinnamon, ginger, and pepper filled the cargo holds of their vessels. The demand for spices was very great, and to the Romans, they were an important source of revenue. At the Roman custom house at Alexandria, imported goods were scrutinized and taxed, and cassia and cinnamon were among those on which tribute was levied.

By the end of the third century at the latest, the Arabians had developed direct sea trade with China, and, in addition to China's cassia, they were probably obtaining spices from Chinese merchants which had come from the East Indies. Envoys from Java were reaching the court of China during the Han Dynasty, 206 B.C. to A.D. 220, and it is most likely that as a result, trade was carried on at that time between the two countries. During the Han Dynasty, it was the practice for those addressing the Emperor to perfume the breath by holding cloves in the mouth, and the cloves had to come from the East Indies because they are not a product of China.

The Arabians may have traded with the East Indies directly. To reach the China coast, they had to pass through the East Indies by way of the

Malacca, Sunda or other straits, and it is to be expected that they would come into contact with the native producers and traders of those islands.

Middle East trade with India and the Far East fell off somewhat in the fourth century, but the spices continued to come through. In that century, Emperor Constantine founded the city of Constantinople on the site of ancient Byzantium to become the capital of the Roman Empire. Its position brought it rapidly into prominence as one of the great trading centers of the Middle East, and the spices of the Orient came to the markets of Constantinople in abundance. That cloves were then reaching the Middle East from the East Indies and enjoying royal use at least is seen from the gift of cloves, saffron and pepper made to the Bishop of Rome by the Emperor Constantine.

Early in the 5th century, Rome was besieged by Alaric, king of the Goths, and part of the ransom demanded from the city was three thousand pounds of pepper, showing that this pungent spice was not less valuable than gold and silver, and indicating the large quantity of pepper then reaching Europe.

In the 6th century, Cosmas Indicopluestis of Alexandria spoke of the importance of Ceylon in the spice trade between east and west. Cosmas, who had been both merchant and traveler, became a monk, and in the retirement of a Sinai cloister, about A.D. 548, wrote a book called *Topographia Christiana*, in which he gives an account of Ceylon or Taprobane as it was known is those days. He tells us that Ceylon enjoyed considerable trade and was "frequented by all nations for the sake of her commerce." To Ceylon, he says, came the "richest merchandise of the Indies, and all sorts of perfumes and spices."

We have seen that cloves were reaching the Middle East by the 4th century at the latest, and in the 6th century, nutmegs may have found their way west in company with cloves, for they are thought to have been known to one Aetius, a resident at the court of Justinian in Constantinople. Nutmegs, like cloves, are native to the Moluccas, a group of islands known as the Spice Islands and situated in the East Indies. It would seem quite reasonable to suppose that where the one spice was found abroad the other was not far away, and nutmegs may have been known in the west as early as cloves. The only fault with this reasoning lies in the assumption that both were considered spices at the same time, when in fact, it is possible that because nutmeg is the shell-enclosed seed of a fleshy fruit, its value as a spice may not have been realized until long after the unopened flower buds of the clove tree had found favor for their aromatic fragrance and pungency.

This last may also be the reason why we can find no early mention of mace. The *macir* of Pliny is not believed to have been mace. Mace is the aril surrounding the shell of the nutmeg. Its scarlet color would have undoubtedly attracted attention when the fleshy nutmeg fruit ripened and split. Indeed, the curiosity of those who first noticed the rich color of the aril may have led to the discovery of the nutmeg. But as the aril possesses the aroma and pungency of the nutmeg to a far lesser degree, its suitability as a spice may not have been appreciated until long after the nutmeg was first exported.

We are now in the Middle Ages. The thousand years between the fall of the Western Roman Empire and the discovery of the New World, or in other words, that period of time between the deposition of Roman Emperor Romulus Augustulus by the barbarian conqueror Odovacar or Odoacer in A.D. 476 and the first voyage of Christopher Columbus in 1492, are usually referred to as the Middle Ages. (The Eastern Roman Empire lasted until the fall of Constantinople in 1493.) These centuries are sometimes called the "Dark Ages" because they were the years of stagnation in cultural and scientific progress between the brilliance of the ancient world and the glory of the Renaissance. Some confine the so-called "Dark Ages" to the four centuries following the fall of Rome. Of course, throughout these years, progress was not actually at a standstill. Learning continued in the monasteries, and the Renaissance or rebirth of learning really began in Italy in the 13th century. The period gave us such great names as Thomas Aquinas, Peter Lombard, Abelard, Roger Bacon, Dante and Chaucer; and three great universities came into existence: The University of Paris, the University of Bologna, and the University of Salerno. Noted travellers were Rabbi Benjamin of Tuleda, Marco Polo, and Ibn Battuta. The church became very powerful and Christianity spread far afield bringing monasteries, abbeys and cathedrals to all parts of Europe and England. Mohammed founded the religion of Islam, and the Moslems became a thunderous power in the world. Charles Martel stopped the Mohammedans at the Battle of Tours in 732; Charlemagne was crowned Emperor of the Holy Roman Empire in 800; William the Conqueror landed in England in 1066 and defeated Harold at the Battle of Hastings; the first crusade took place in 1095; and King John signed the Magna Charta in 1215.

Commerce between Europe and the East was limited, and trade in Europe and in European waters was hampered by many factors, including robbers pirates, poor roads and methods of transportation. Shipping was undeveloped and boats cumbersome and slow. Taxation was heavy and merchants were compelled to pay tribute at every castle, abbey, town and province. The guild system came into existence and craft guilds and merchant guilds were organized. Guilds had existed in the ancient world; they were a part of the industrial life of China, and of Constantinople. The two large customers of the medieval merchants were the nobility and the church, both wanted luxury goods and the spices of the Orient. The Moslems controlled the spice trade in eastern waters, and Alexandria and Constantinople came to know an increasing demand from European merchants for the spices of India and the Far East. Among them, the Venetians rose rapidly to prominence. The Italians were helped considerably by the crusades, receiving for their aid trading privileges in conquered lands which went far to consolidate their commercial interests with Asia. The spices from the East enriched the princes of the Middle East and turned the merchants of Venice into princes. All Europe paid tribute to Venice. And Venice, through her commerce with the East, contributed much of her wealth to the service of art to usher in the Renaissance; Leonardo da Vinci and Michelangelo came in the 15th century.

During the Middle Ages in Europe, small lots of costly oriental spices were reaching ecclesiastical groups as gifts or supplies. We read that cassia and cinnamon were mentioned by St. Isidore, Archbishop of Seville, and that the Venerable Bede had collected some of the spices of the East in the monastery of St. Peter and St. Paul at Jarrow, England. In the grant made to the monastery of Corbie in Normandy, in the year 716, by Chilperic II, king of the Franks, cinnamon and cumin are included among the spices and groceries. In the year 745, Gemmulus, a Roman deacon, sent a gift of cinnamon and pepper to Boniface, Archbishop of Mayence. Lullus, the successor to Boniface, sent a present of cinnamon to Eadburga, third Abbess of Minster in the Isle of Thanet in Kent. In the 9th century, cinnamon, cloves, and pepper, together with indigenous aromatic plants, "were used in the monastery of St. Gall in Switzerland as ingredients for seasoning fish."*

The cultivation of spice herbs was encouraged by Charlemagne, about 742 to 814, and in the royal gardens, fennel and fenugreek grew.

In the Statutes of Ethelred, 978—1016, it is enacted that the Easterlings coming to Billingsgate should pay a tribute of pepper along with other goods for the privilege of trading with London.

In the 12th century, there was a Pepperers Guild in London. And by the end of that century, nutmegs and mace had found their way to Denmark and other parts of northern Europe. It is recorded that in those days, nutmegs were employed to fumigate the streets of Rome before the entry of Emperor Henry VI for his coronation.

Rabbi Benjamin, the son of Judas of Tuleda, traveled in that century, from 1160 to 1173. He made his way, through Europe, Africa, and Asia, from Spain to China. At Alexandria, he found a multitude of traders from all parts of the world, who imported all kinds of spices from India or traded in spices in this "excellent market to all nations." In the fields bordering on the Nile, he saw coriander growing. In Bagdad, he found sixty hospitals "all well provided from the king's stores with spices." He marveled at the magnificence of Constantinople, and he was impressed with the great trade of the city. In the Persian Gulf he found the Island of Qais famous because of the commerce of India, whose merchants brought an enormous quantity of spices to the island. Sometime later, the trade of this island passed to the Island of Hormuz; the great traveler Ibn Battuta, visiting the Persian Gulf in the early part of the 14th century, speaks of an island lying nine miles off shore called New Hormuz and remarks on its fine city and busy markets.

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* *Pharmacographia,* pages 522, 523.

The most famed traveler of the Middle Ages was Marco Polo, who in the 13th century visited the court of Kublai Khan, Grand Khan of the Mongols Emperor of China. From Marco Polo, we learn something of the place of the spices in the lives of the people of eastern Asia.

VII. SPICES IN THE TRAVELS OF MARCO POLO

MARCO POLO was born in Venice in the year 1245. His father, Nicolo, and his uncle, Maffeo, returned in 1269 from a nine-year trading expedition into Asia, which had taken them as far as the court of Kublai Khan. The brothers had been favorably received by the Great Khan who enquired of them concerning the western world, and in particular, about the Pope and the doctrine of Christianity. He prepared letters requesting the Pope to send a hundred men qualified to instruct his subjects in the western arts and Christianity and gave them into the care of the Polos for delivery to the Pope of Rome. He also requested that they bring him on their return to his court "some of the Holy Oil from the lamp which is kept burning over the sepulchre of our Lord Jesus Christ."

When the Polos arrived at Acre, in the month of April 1269, they learned that Pope Clement IV was dead. After a consultation with the papal legate resident in Acre, they decided to continue to their home in Venice and there await the election of a new Pope.

After an elapse of two years, and no papal election, the Polos decided it was not advisable to delay any longer their return to the court of Kublai Khan. Taking Marco, who was then seventeen years old, they visited Jerusalem and obtained some of the Holy Oil, and then went to Acre were they received from the papal legate explanatory letters addressed to the Great Khan. Thus prepared, the three Polos started out on their journey across Asia.

They had not travelled far when word reached them that the papal legate at Acre had been elected Pope. They immediately returned to Acre where the new Pope, Gregory X, delegated two learned friars, to whom he gave letters and presents for the Great Khan, to accompany the Polos east and there fulfill the wishes of the Mongolian Emperor.

The party sailed for the port of Laiassus in Asia Minor, from where they proceeded inland. Being merchants, the Polos were keenly observant of matters pertaining to trade, and conscious of so valuable a commodity as spices. Marco Polo first mentions spices when describing the traffic in the

Port of Laiassus, which, he says, "is frequented by merchants from Venice, Genoa, and many other places, who trade in spices and drugs of different sorts, manufactures of silk and of wool, and other rich commodities." The journey had hardly commenced, when the two friars, hearing reports that invading armies were laying waste to Asia Minor, and fearing for their lives, gave the letters and presents to the Polos and returned home. Both Nicolo and Maffeo had known many perilous experiences and they were not dismayed, and Marco was a stouthearted young man, so the three carried on.

Arriving in Mosul, the Polos found "great merchants" called Musulini who conveyed large quantities of spices and drugs from one country to another. These merchants seem to have been among the leading spice traders, using the caravan routes of western Asia at that time. They probably obtained their spices at Bagdad on the Tigris. And, undoubtedly, they met the spice caravans from the East somewhere along the route through northern Iran. Speaking of the Tigris, Marco Polo says:

> ...the merchants transport their goods to and from the Sea of India; the distance being computed at seventeen days' navigation, in consequence of the windings of its course. Those who undertake the voyage, after leaving the river, touch at a place named Kisi, from whence they proceed to sea.

Kisi is the name given by Marco Polo to the island of Qais, then an emporim for spices from India.

The perils and hazards to which the traders of his day were exposed in that part of western Asia are vividly illustrated by Marco Polo's description of the deserts, extensive tracts of sand, lack of vegetation, and long distances between watering places on the route through Iran. He also tells of marauding bands of "unprincipled" mountain-living Kurds who preyed upon merchants passing through the province of Mosul.

Traveling by way of the kingdom of Kerman and the town of Kamandu, or over what would now be a route east by south through Iran from Bagdad, the Polos, after passing through warm fertile plains and then perishing mountain passes infested with robbers, eventually reached the coast of the Persian Gulf and the city of Hormuz. Here the Polos found many Indian merchants who brought to this city great quantities of spices and other valuable commodities from across the sea.

Marco Polo was particularly critical of the one-deck, singlemast vessels built at Hormuz and used in the Indian trade. He considered them unseaworthy and a menace to the merchants and sailors who had to cross the ocean in them. Among other faults, the ships were not equipped with iron anchors but a kind of ground-tackle, with the result that many were driven ashore during heavy weather.

The route taken by the Polos on their journey from Hormuz to the court of the Great Khan may be traced on a modern map as follows: Leaving Hormuz, they travelled north through Iran toward the town of Mash-had and then in an easterly direction through part of Turkestan and the northeast corner of Afghanistan; from there they continued across the Pamir Plateau to Kashgar, Yarkand, and Khotan. From Khotan, they journeyed in sight of the Kunlun mountains to pass south of Lop Nor and then crossed the Gobi desert to Suchow, Kanchow, Liangchow; finally, they traveled along the bank of the Yellow River and east to Shandu (which might be Chengte, a city about 100 miles northeast of Peking), where Kublai Khan had his summer palace.

On this journey, Marco Polo mentions the use of sesame-seed oil by the people of the province of Balashan (northeast corner of Afghanistan) and observes that sesame oil "is better and has more flavor than any other."

The crossing of Asia by the Polos occupied three and a half years, and Marco Polo was twenty-one years old when they arrived at the royal court, in the year 1275. In an assembly befitting the occasion, the brothers Nicolo and Maffeo were graciously received by the Great Khan, and after the presentation of the letters, presents and Holy Oil, Marco was formally introduced to the Emperor, who expressed great pleasure and warmly welcomed the young man to his court.

Marco Polo quickly adapted himself to the manners of the people and applied diligence to the task of learning to speak, read, and write four different languages then used in the empire of the Khan. This accomplished, the Great Khan sent him on confidential missions to all parts of the empire and its dependencies. In his notes about these affairs, he made many references to spices.

He described the city of Peking, the capital of Kublai Khan, as a busy, populous place to which came a great flow of spices from India. The people of Peking enjoyed a "clear, bright, and pleasant" wine made from rice, so well flavored with spices, and so good that it made "one drunk sooner than any other wine." This, of course, would be but one of a great many uses for the spices in those days.

In the country bordering on the Yellow River in Shansi province, ginger was produced in large quantities, and across the river in lower Shensi, this spice was grown in "great abundance."

In the province of Kain-du (Yunnan), ginger and cassia grew in abundance. Here the people drank a spiced wine made from wheat and rice. According to Maro Polo, this province produced cloves:

> The tree is small; the branches and leaves resemble those of the laurel, but are somewhat longer and narrower. Its flowers are white and small, as are the cloves themselves, but as they ripen, they become dark colored.

We have already said that cloves were long known to the Chinese, but as we have also pointed out, cloves are native to the Spice Islands of the East Indies and not found growing in China. We do not believe Marco Polo saw the clove tree in Yunnan or any other province of China. He probably saw the spice itself in Yunnan or was informed of its presenced there, but his notes on the description of the clove tree must have been made from hearsay while he was in Yunnan or later when he was in Java. If he ever saw the clove tree, then Marco Polo must have visited the Molucas. The flowers of the clove tree are not white as Marco Polo says, but rosy in color. In stating that the cloves are at first white and as they ripen become dark colored, he was not altogether wrong; they are, in fact, at first white, then become green, next yellowish with a pink tint, and finally a dull blood red.

In the province of Karazan, the higher-class people ate meat which had been pickled in salt and "several of their spices," but the poor folk had to be content with meat which had been cut into small pieces and steeped in a "sauce of garlic." Apparently they all drank spiced wine.

The people of Kardandan province ate their meat raw or prepared as above and indulged in spiced wine. They were ancestor worshippers and resorted to sorcery for the cure of sickness. Incantations were accmpanied by the throwing of a spiced brew into the air, followed by feasting on the sacrificial meats and drinking of the spiced brew with "great hilarity.'

Bengal, a province visited by Marco Polo, but not under the dominion of the Great Khan, produced considerable quantities of ginger which attracted merchants from many parts of India.

In the country surrounding the "large and magnificent" city of Soochow, ginger was produced in such large quantities that forty pounds of the root could be bought "for the value, in their money of a Venetian silver groat." In the kingdom of Kon-cha, ginger was a principal export; it was so abundant that a Venetian silver groat would buy eighty pounds.

In the "noble and magnificent" city of Hangchow, Marco Polo found a population of "one million six hundred thousand families," and he marveled at the quantity of food necessary to feed such a large number of people. He was informed by an officer in the customs service of the Great Khan that the daily amount of pepper bought was forty-three loads, each load being two hundred and forty-three pounds, or a total of 10,449 pounds! In such a heavily populated city, trade was very great and in the ten market squares, there was always to be found "a great variety of herbs" and spices. The natives were "accustomed to their own liquor prepared from rice and spices."

The "noble and handsome" city of Zai-tun, he says, has a port on the sea-coast celebrated for the resort of shipping.

> The quantity of pepper imported there is so considerable that what is carried to Alexandria to supply the demand of the western parts of the world is trifling in comparison, perhaps not more than the hundredth part.

From this immense pepper trade, Kublai Khan derived a handsome revenue and the spice merchants made a most respectable profit despite customs, freight, and other charges which amounted to fifty per cent of the value of the pepper cargo.

Dscribing the islands of the China Sea, Marco Polo says, "of the trees which grow in them, there are none that do not yield a fragrant smell. They produce many spices and drugs, particularly lignum-aloes and pepper, in great abundance, both white and black." He said he had not visited these islands personally, but got his information from pilots and mariners frequenting the islands. Actually, these would be the islands of the East Indies where, in fact, he had been according to a statement he makes elsewhere and where he had at least visited Java.

And speaking of Java, he says the country abounds with rich commodities, "pepper,nutmegs,...cloves, and all other valuable spices and drugs are the produce of the island; which occasion it to be visited by many ships laden with merchandise that yields to the owners considerable profit....and from thence also is obtained the greatest part of the spices that are distributed throughout the world."

The Polos remained in China for seventeen years and gained considerable wealth "in jewels of value and in gold." They then wated to return to their native land, but the Great Khan would not hear of such a thing. Fortunately, at this time a request for a bride came from King Argon of Persia who had recently been bereaved of his queen. The late queen had come from Cathay and in fulfillment of her last request, Argon sought a maiden to wife from among her relatives.

The future consort, "a damsel aged seventeen, extremely handsome and accomplished," having been found, she and her attendants set out on the overland journey to Persia. However, after eight months of travel the difficulties of the route compelled them to return to the court of the Great Khan. At this time, Marco Polo had just returned from a voyage to the East Indies, and he, together with his father and uncle, conferred with the ambassadors of Argon on the matter. Here was their opportunity to get out of China. They approached Kublai Khan and tactfully suggested that as the overland journey was impossible, they, as skilled navigators, might be entrusted with the responsibility of conveying the young lady by sea to Persia. The Great Khan was very much displeased, but realizing the urgency of the matter he reluctantly consented.

After the ships had been made ready for the voyage and stored for two years the party sailed from Zaitun, south along the coast to Indo China, across the Gulf of Siam, through the Straits of Malacca, across the Indian Ocean to Ceylon, and up the west coast of India to the Persian Gulf. On their arrival in Persia, they were informed that Argon was dead and, on the instructions of the government, delivered the young princess into the care of his youthful son. From Persia, the Polos went on to Venice by way of Constantinople and arrived home in the year 1295, "in the enjoyment of health and abundant riches."

Of the spices noted on his voyage home from the Straits of Malacca, Marco Polo mentions cloves in the Nicobar Islands, oil of sesame in Ceylon, and an abundance of pepper, ginger, and cinnamon on the Malabar coast of India.

It is a strange and interesting thing that Marco Polo does not mention cinnamon when speaking of Ceylon. The finest and most fragrant cinnamon, from *Cinnamomum zeylanicum,* is native to Ceylon, but, for some unknown reason, its presence on the island seems to have remained unnoticed until the late 13th century when it is mentioned in the work of an Egyptian historian. In fact, apart from Marco Polo's reference to sesame, he does not mention spices at all when describing this island, yet the spice trade of Ceylon had been noted by previous travelers.

Marco Polo also tells us of the use of oil of sesame in Abyssinia; of the port of Aden "frequented by ships arriving from India with spices and drugs"; and of a city named Kalayati situated three hundred miles southwest of Hormuz, where many trading vessels arrive from India loaded with spices which they sell to great advantage.

In the year 1298, war broke out between Genoa and Venice and, in a sea fight on September 7th of the same year, the Venetians were defeated and Marco Polo, who was a "Gentleman-Commander" of a Venetian galley, was captured and imprisoned in Genoa. He was released within a year, but during the months of his confinement, having obtained his notes, he dictated his story to one Rusticano of Pisa, a scribe and fellow prisoner, who recorded the narrative on parchment.

Few people believed the story of Marco Polo and, when asked on his deathbed in 1324 to retract some of the seemingly incredible statements made in his book, he replied, "I have not told half of what I saw."

From the experiences of Marco Polo, we get an impressive idea of the conditions of travel in his day. The Asiatic traders, with their heavily burdened and slow-moving camels, crossed many a stretch of fertile plain where good food and clear, sweet water were plentiful, but they also endured the loneliness of miles of barren, uninhabited country, and knew the fear of desolate and trackless desert land where food was not to be found and water was often stagnant, briny, and sickening. In wild, mountainous country, they climbed through narrow and dangerous passes where the disturbing cries of birds and beasts echoing from the crags and caverns rent the air about them. And not infrequently, they were attacked by roving bands of bloodthirsty robbers who savagely cut them down and made off with their treasured goods.

Those who traveled by sea did not find conditions better. Bad and cramped accommodation, poor food, exposure, storms, and shipwreck were their common lot. Crowded in dismal and unsanitary quarters, half starved and exhausted men, soaked by the heavy seas which swept their little vessels from stem to stern, or parched for the want of pure water, while their ships lay becalmed for weeks in stifling tropical heat, sickened and died; death was always a shipmate. Pirates infested the seas in those days and many a ship and cargo fell into their lawless hands.

Marco Polo had knowledge or experience of all these things. Early in his narrative, he intimates that he had met with bitter attack on one occasion from which he had escaped, but in which many of his companions were taken and sold or put to death. And effectively he recounts the trying experiences of travel by land. Of the Gobi desert he says:

> To travel it in the direction of its length would prove a vain attempt, as little less than a year must be consumed, and to convey stores for such a period would be found impracticable. During these thirty days the journey is invariably over either sandy plains or barren mountains; but at the end of each day's march you stop at a place where water is procurable; not indeed in sufficient quantity for large numbers, but enough to supply a hundred persons, together with beasts of burden. At three or four of these halting-places the water is salt and bitter, but at others, amounting to about twenty, it is sweet and good. In this tract neither beasts nor birds are met with, because there is no kind of food for them.
>
> It is asserted as a well-known fact that this desert is the abode of many evil spirits, which amuse travelers to their destruction with most extraordinary illusions. If, during the day-time, any person remain behind on the road, either when overtaken by sleep or detained by their natural occasions, until the caravan has passed a hill and is no longer in sight, they unexpectedly hear themselves called to by their names, and in a tone of voice to which they are accustomed. Supposing the call to proceed from their companions, they are led away by it from the direct road, and not knowing in what direction to advance, are left to perish. In the night-time they are persuaded they hear the march of a large cavalcade of people on one side or the other of the road, and concluding the noise to be that of the footsteps of their party, they direct theirs to the quarter from whence it seems to proceed. But upon the breaking of day, they find they have been misled and drawn into a situation of danger. Some-

> times likewise during the day these spirits assume the appearance of their travelling companions, who address them by name and endeavor to conduct them out of their proper road. It is said also that some persons, in their journey across the desert, have seen what appeared to them to be a body of armed men advancing towards them, and apprehensive of being attacked and plundered have taken to flight. Losing by this means the right path, and ignorant of the direction they should take to regain it, they have perished miserably of hunger. Marvellous indeed and almost passing belief are the stories related of these spirits of the desert, which are said at times to fill the air with the sounds of all kinds of musical instruments, and also of drums and the clash of arms; obliging the travelers to close their line of march and to proceed in more compact order....Such are the excessive troubles and dangers that must unavoidably be encountered in the passage of this desert.*

The following extract from his account of the voyage from China to Persia will indicate the terrible hardships endured and the high death toll resulting from the indescribable miseries of ship life:

> But here it may be proper to mention, that between the day of their sailing and that of their arrival, they lost by deaths, of the crews of the vessels and others who embarked, about 600 persons.

There were fourteen ships and a total complement approaching or perhaps exceeding 1200 souls, and actual sailing time was about twenty-one months.

The traveling spice merchants of those days experienced all these conditions, but trade went on just the same and the spices moved east and west to meet the ever-increasing demand. We have seen how great was the spice trade to the west and from Marco Polo, we have learned of the great movement of pepper to the China coast.

Marco Polo gives an interesting account of the pepper ships trading to China. They were single-deck vessels built of fir and double planked. The planks were fastened with iron nails, and caulked with oakum. In the absence of pitch, the hull was smeared with a mixture of ointmentlike consistency made by pounding together finely cut hemp, quicklime, and the oil of a tree which he does not name. Marco Polo held this material to be better than pitch since it retained its resistant properties longer. The holds were fitted with a number of watertight bulkheads to prevent undue loss of cargo in the event of springing a leak. The larger ships had four masts and the smaller, two. They were fitted with many sails, but were also constructed for oar propulsion, each sweep requiring the work of four men for its manipulation. The number of crew varied with the size of the ship from 150 to 300 men. Small, single-berth cabins were provided below deck for the accommodation of merchants, a large vessel having about sixty of these cabins. Cargo capacity was from 5,000 to 6,000 baskets or mats of pepper.

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* *The Travels of Marco Polo*, book 1, chapter 39.

The larger ships were accompanied by two or three barks, having a cargo capacity of 1,000 baskets of pepper. These vessels carried crews of 60, 80, or 100 men. Slung overside, all vessels carried small boats for the purpose of carrying out anchors, fishing, "and a variety of other services."

Marco Polo does not tell us how these ships were navigated. We imagine that the land was kept in sight as long as possible, which accounts for his comment on the lack of iron anchors on the vessels built at Hormuz, but at times they must have crossed wide gulfs or ventured into the deeps to take advantage of favorable trade winds. They could guide themselves by the sun during the day, and steer by the Pole Star at night; how they managed when sun and stars were clouded over, we do not know. Marco Polo does not speak of the use of a compass. However, by sun or star, lodestone or magnetized iron needle, these ships, not large by our standards, crowded and cramped, made their way to China heavily laden with pepper which brought a handsome profit to the spice merchants who risked their lives in them.

VIII. SPICES AND THEIR USES IN THE LATE MIDDLE AGES

BY the 13th century the East Indies were the scene of a thriving trade in spices. Java was the principal spice-trading island, and Javanese traders brought the cloves, nutmegs and mace from the islands of the Molucca groups for distribution to the world. Numerous Chinese junks reached the coast of Borneo and, from there, traded among the clove and nutmeg islands. From Java, Arabian merchants sailed west with their ships laden with pepper, cloves, nutmegs, mace, cassia, and ginger, in addition to their spice trade with southern India; and Chinese merchantmen carried pepper, cloves, nutmegs and mace to the ports of China. The East Indies gradually eclipsed the Malabar coast of India as the most important source of costly spices and both places attracted the princes and merchants of western Europe to bring, in the 15th and 16th centuries, the greatest and brightest age of discovery the world has ever known.

China continued to export her cassia, of which large quantities grew in Kwangsi province and Cochin China, to the west. Her ginger probably went no farther than neighboring Burma and the eastern provinces of India. Burma was not a producer of spices, but a consumer of no small account, if we believe the contents of an ancient inscription which says that the 13th-century king Narathihapate ate three hundred dishes of curry daily.

The consumption of spices was steadily increasing in the west, and in the fairs of Europe and England oriental spices were regularly obtainable. In 13th-century England, mace was four shillings and sevenpence per pound, ginger one shilling and sixpence, pepper one shilling, cassia tenpence, and cumin twopence. These were high prices in those days, but understandable when we consider the long and hazardous voyages and overland journeys from the East, and the number of hands through which the spices passed.

There is little mention of spices in the next century. Saffron is believed to have been introduced into England in the 14th century. According to Hakluyt, "...a pilgrim purposing to do good to his countrey, stole an head of saffron, and hid the same in his palmers staffe, which he had made hollow before of purpose, and so he brought this root into this realme, with venture of his life: for if he had bene taken, by the law of the countrey from whence it came, he had died for the fact."*

De Candolle writes that "saffron was cultivated in very early times in the west of Asia."** And Hakluyt observes that saffron "groweth fifty miles from Tripoli in Syria, on an high hill called in those parts Garan."† The pilgrim would be returning from a journey to the Holy Land and passing through those parts.

If the story is true, this unknown traveller is to be commended for his sagacity if not his honesty, for his solitary bulb was the start of an enormous production of saffron in Essex and Cambridgeshire through two centuries. The town of Saffron Walden in Essex is named for it. According to Hakluyt it provided work for many poor people and brought great wealth to the country.

It would appear that by the time of Hakluyt's writing (1582) the market for saffron had fallen off and the production of this spice had declined considerably. Observing that "the best of the universall world groweth in this realme" he pleads, "if a vent might be found, men would in Essex and Saffronwalden and in Cambridge shire revive the trade for the setting of the poore on work."††

In 14th-century England, spices were still exacted as tribute or taxed for certain purposes. For example, in the reign of Edward I, we find that anise was among the commodities taxed to raise the funds required to defray the expense of repairing London Bridge. A new guild of Pepperers was organized in London in 1345. The Pepperers were among the wealthiest of merchants, and one had to be a pepperer of Soper Lane or a spicer of Cheap, in good standing, to belong to the fraternity. Cinnamon, pepper, and other spices were conveyed to the warehouses of the spice merchants by street porters, whose charges were a matter of agreement between themselves and the Pepperers Guild. Cassia buds were mentioned in this century: they were sold in London at eight to thirteen shillings per pound. Pepper increased in price to two shillings per pound.

The high prices asked for spices put them beyond the reach of the poor people. Listen to the impassioned plea of John Ball, known as the "Mad Priest of Kent," an ardent advocate of socialism who flourished in the restless years following the Black Death and who was executed at St. Albans in 1381:

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* *Hakluyt's Voyages,* Vol. 3, p. 98.

** *Origin of Cultivated Plants,* Alphonse De Candolle, p. 166.

† *Hakluyt's Voyages,* Vol. 3, p. 98.

†† *Ibid.*

> By what right are they whom we call lords greater folk than we? They are clothed in velvet, and warm in their furs, while we go covered with rags. They have wine and spices and fair bread, and we eat oatcake and straw and water to drink.

Most decidedly, the spices were beyond the poor folk of those days, but the situation could hardly have been otherwise. All Europe depended on the Orient for pungent and fragrant spices: cloves, nutmegs and mace came from the Moluccas; pepper from southern India and Java; cassia from China and the East Indies; cinnamon from Ceylon and Malabar; and ginger from Malabar and perhaps the East Indies. And because there was no Suez Canal and no known road to the Orient, except through the lands of the Middle East, Europeans could not trade directly with those places.

The Arabs practically monopolized this trade in eastern waters and the merchants and bankers of Venice controlled the spice trade in the Mediterranean. After leaving the hands of the native producers, the spices passed through numerous dealers before they reached the markets of the Black Sea and the Eastern Mediterranean and with each change of ownership came an addition to the cost.

The balance of trade was in favor of the Orient and to pay for the spices of the East, Europe shipped her gold and silver through Venetian banks, making the already wealthy merchants of Venice wealthier and adding to the fortunes of the royal coffers of the Middle East. But the people of the West were learning. Merchants and bankers in western and northern Europe were growing slowly more powerful; shipyards were building better ships; inquiring minds were busy; and eager, searching eyes were scanning the maps of the geographers.

Alexandria, Constantinople, and Venice had enjoyed a glorious day, but the sun was setting and the shadows of darkness lengthening. Six years before the 14th century slipped into the past, the great instigator of discovery, the man whose efforts were to lead to the finding of the all-water route from western Europe to India and usher in the age of European commercial supremacy, first saw the light of day in the palace of John I, king of Portugal. But before we look at the life of Prince Henry the Navigator, let us turn briefly to the place of the spices in food, medicine, story, and fable during the Middle Ages.

There were no manufactured foods in those days and no cold storage chambers in which to store meat, game, and fish for a time of scarcity. The preservation of food depended on salting, drying, or smoking; the quality and variation of dishes on the skill of cooks. In the long winter months, the fare could not be other than dull and insipid under the best of conditions.

The coming of the highly aromatic and pungent spices of the Orient was the greatest boon to European food and cookery of all times. New methods of preserving food quickly came into existence; dishes took on a fullness of flavor previously unknown; beverages glowed with a redolent tang, and life experienced a new sense of warmth and satisfaction.

In the peasant home, we would not find the costly spices of the East. But in the kitchens of the great, could we but watch the cooks, we would see them finely chopping the mace or scraping the nutmeg, pounding the cassia or cinnamon, or perhaps the ginger, in the mortar, or grasping a few cloves to flavor the pottage, fish, game, barbecued meat, and dainties which provided the fare of the lords and ladies.

Every chef had his own ideas of seasoning and flavoring and every master his favorite spice. They used small, fragrant sticks of cinnamon and the delightful little clove buds to garnish dishes; pepper, cloves, ginger, mace, and onions stuck with cloves were common ingredients of pottage; clear soups were strained through bunches of fragrant herbs; anise, mint, and parsley were among the spices held best for gravies, sauces, and relishes; dill flavored their vegetables and, in the later centuries, was used for pickling cucumbers; chervil, a herb believed to have been brought to England by the Romans, was considered essential in salads and was used for flavoring soups and sauces, and for garnishing; saffron was added to soups and used in sweetmeats; tarragon was added to salads; caraway and cumin flavored their soups, cheese, bread, and cakes and were used in the preparation of dainties; fennel and coriander seeds were sugared and eaten as confections; oil was expressed from nutmeg and mace to flavor a dainty butter; cassia, cinnamon, cloves, nutmeg, mace, ginger, anise, sweet marjoram, thyme, and savory were employed to flavor puddings, tarts, pastries, cakes, and conserves; and rosemary, nutmeg, cinnamon, fennel, coriander, anise, cloves, and ginger went into the preparation of their many kinds of beverages, wines, and liquors.

Throughout the Middle Ages, the medicinal uses for the spices were not dissimilar from those of the ancients. The Anglo-Saxons turned to the herbs for most of their remedies and in their leech-books are found the names of many spices. In the *Herbarum Apuleii Platonici*, said to be a 5th century work, but published in the 10th century, we find mention of coriander, dill, fennel, mint, marjoram, parsley, and sage. Coriander is held a remedy "in case that round worms wax or grow about the navel"; and these seeds, if knit with a thread on a clean linen cloth and held by a boy or maiden at the left thigh "near the natura" of a woman in labor, will quickly bring the child to birth. Dill is prescribed for itch, for "sore of the shapes," and for headaches. Fennel is recommended for the treatment of coughs and congestion of the chest, and for "sore of the bladder." Marjoram is held a remedy for burns and headache. Mint is recommended for the treatment of bad cuts or wounds on the head; pounded with sulphur and vinegar and smeared on the patient with a new feather it is beneficial in case of tetter and pimples on the body. Parsley is held a remedy for bites of the adder, and for sore sinews. And sage is prescribed for itching of the "shapes, settle, or seat."

A Leechbook or Collection of Medical Recipes of the Fifteenth Century (Text of MS No. 136 of the Medical Society of London), by Warren R. Dawson, mentions some twenty-six spices in its collection of prescriptions. This work gives us a good idea of the place in medicine of the spices during the Middle Ages. Here are some of the more interesting remedies given in this leechbook. For the chest and cough, a decoction called Wine of Tyre or Tiberias, is recommended. This wine includes fennel, parsley, thyme, sage, savory, rosemary, marjoram, cloves, pepper, mace, nutmeg, cinnamon, and ginger. It must have been very powerful! For the bites of dogs and adders, and the bites and stings of "venomous worms," garlic, and sometimes garlic and onions, is prescribed. To cure aching loins, the patient is advised to take nine peppercorns.

A powder, made with anise, cinnamon, cardamom, origanum, caraway, fennel, sage, cumin, thyme, black pepper, parsley, ginger, cloves, and saffron, will cleanse the brain, do away with headaches, clarify the sight, aid the digestion, and destroy wind!

Laurel leaves are recommended for cramp; cloves for evil ears; cumin for gout, and for gnawing and fretting in a man's limbs, bones, or side; parsley for black eyes; pepper, sage, and mustard for colds; onions to make the hair grow; and savory with wine to bring about the deliverance of a dead child.

And here was a tip to the medieval spice merchant:

> A good electuary for a spicer to gather for his trade to give and sell. Take honey and baking-flour, ginger, and the powder of pepper, and barley-wort; and seethe them together till it be standing, and then sell it forth.

In the Middle Ages, the people had great faith in spices as a protection against contagious diseases. Giovanni Boccaccio refers to this use of spices when describing the terrible and devastating Bubonic plague, called the Black Death, which swept over Europe in the middle of the 14th century. In his *Decameron*, he says:

> In this sore affliction and misery of our city [Florence, Italy]...many others...went about, carrying in their hands, some flowers, some oderiferous herbs and others some divers kinds of spiceries, which they set often to their noses, accounting it an excellent thing to fortify the brain with such odors, more by token that the air seemed all heavy and

> attainted with the stench of the dead bodies and that of the sick and of the remedies used.*

Rosemary was highly esteemed for this purpose because it was thought to shield and protect the wearer from all manner of infection when in the presence of the sick, or when attending funerals.

Just following the period usually considered the Middle Ages, there lived a number of notable herbalists, for example, Grattarola of Bergamo, Turner, Gerard, and Culpeper. We feel that we should at least give you some information from the work of one of them and we have selected the *Herbal of Gerard.* John Gerard, 1545—1612, English herbalist and surgeon, sometime superintendent of the gardens of William Cecil, Lord Burghley, had his herb garden where Fetter Lane (near Temple Bar, Fleet Street, London) is seen today. His herbal was published in 1597.

Gerard confirms the statement of Dioscorides that ginger is "right good with meat in sauces," and says that this spice is "of an eating and digesting quality, and is profitable for the stomach, and effectually opposeth itself against all darkness of the sight; answering the qualities of pepper."

He greatly esteemed rosemary and tells us that if the flowers of this spice are distilled and a few cloves, mace, cinnamon, and a little aniseed steeped or infused in the distillate for a number of days, the concoction, drank first thing in the morning and last thing at night, will take away the stench of the mouth and make the breath very sweet. The Arabians and other physicians, he says, write that rosemary "comforts the brain, the memory, the inward senses, and restores speech unto them that are possessed with the dumb palsie, especially the conserve made of the flowers and sugar, or any other way confected with sugar, being taken every day fasting." He concludes: "The flowers [of rosemary] made up into plates with sugar after the manner of Sugar Roset and eaten, comfort the heart, and make it merry, quicken the spirits, and make them more lively."

Following the ancient belief, he tells us that the powdered seed of fennel preserves the eyesight if "drunke for certaine daies together fasting."

Saffron, which he says "growth plentifully in Cambridgeshire, Saffron-Waldon, and other places thereabout," strengthens the heart, opens the lungs and removes obstructions. He says ten or twenty grains with new or sweet wine is a special remedy for those who have consumption and are "at death's door" and almost past breathing, "that it bringeth breath again, and prolongeth life for certaine daies." "For we have found by experience," he assures us, that taken as above "it presently and in a moment removeth away difficulty of breathing, which most dangerously and suddenly hapneth."

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* *The Decameron,* page 11.

Gerard quotes Avicenna* as affirming saffron in moderate use is good for the head, making the senses quick and lively, shaking off heavy and drowsy sleep, and making a man merry, but used excessively it causes headaches, induces sleeplessness, and hurts the brain.

Now let us look at the romance of the spices in the Middle Ages. Albertus Magnus (1206—1280?) gifted teacher, philosopher, theologian, and writer, gives us an interesting titbit about laurel or bay leaves. He says that if one gathers heliotropin in August and wraps it in a bay leaf with a wolf's tooth, no one can speak angrily to he who wears it; if put under the pillow of one who has been robbed, it will bring in a vision "the thief and all his belongings." And if it be set up in a church, any women of the congregation who have broken their marriage vows will not be able to leave the place until the bay leaf and its contents have been removed; he says "this last is tried and most true."

There are many references to spices in *The Canterbury Tales*, written by Geoffrey Chaucer (1340—1400). The following are among the more interesting:

The herbs were springing in the vale:
Green ginger plants and liquorice pale
And cloves their sweetness offer,
With nutmegs too, to put in ale
No matter whether fresh or stale,
Or else to keep in coffer.
—Chaucer's Tale of Sir Topaz**
Spicery, root, bark, leaf—they search and cull it
In the sweet hope of flattering a gullet!
—The Pardoner's Tale***
They danced and drank and, left to their devices,
They went from room to room to scatter spices
About the house.
—The Merchant's Tale†
That claret laced with spice can lend desire;
—The Merchant's Tale††
The steward bids them hurry with the spices and fetch the wine,...
—The Squire's Tale†††

In the *Decameron* of Boccaccio, published in the year 1353, we read in *The Fifth Story of the Fourth Day* of poor Lisabetta and her pot of basil. Lisabetta's brothers slay her lover and he appears in a dream to show her where he is buried. Quietly and unseen she goes to the grave and disinters the body, removes the head with a knife and wraps it in a napkin, and then reburies the trunk. Back in her chamber she cries bitterly in her grief, and then takes a good sized pot used for growing marjoram or basil and places the head of her lover, wrapped in a linen cloth, inside. She then covers the head with soil and plants in it sweet basil of Salerno. She waters the basil with her tears and rose or orange-flower water, and spends her days in meditation and weeping, gazing longingly upon the pot and watching the basil grow "fair and very sweet of savor." The brothers, noticing her strange behavior and wasted beauty, secretly remove the pot of basil and, looking beneath the soil, they find the head of their sister's lover. Thoroughly alarmed, they hurriedly buried the head and decamped to Naples. Poor Lisabetta's grief was beyond her and she fretted her life away and died weeping.

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* Avicenna or Ibn Sina, 980-1037, Arabian philosopher and physician.

** *The Canterbury Tales*, page 202.

*** *Ibid.*, page 271.

† *Ibid.*, page 395.

†† *Ibid.*, page 396.

††† *Ibid.*, page 421.

In *The Seventh Story of the Fourth Day*, Simona and her lover Pasquino solaced themselves in a garden at the side of a sage bush, from which Pasquino plucked a leaf and rubbed it on his teeth and gums saying that it was good to clean the teeth. But within a few minutes he sickened and died. Accused of poisoning her lover, Simona directed the judge to the garden to show him exactly what happened, and taking a leaf from the sage bush she too rubbed her teeth and gums only to drop dead herself. Knowing that sage is not poisonous, the judge ordered the sage bush to be uprooted and burnt. Carrying out these instructions the gardener found a huge toad under the bush, and it was concluded that its "pestiferous breath" had poisoned the sage.

In *The Second Story of the Eighth Day*, we read of the parish priest of Verlungo and his affair with Mistress Belcolore. Seeking the goodwill of the lady, he repeatedly sent her cloves of garlic from his own garden. His desires were gratified!

In *The Arabian Nights* (*The Thousand and One Nights*), a collection of tales supposed to have been told by Scheherazade, wife of the Sultan of the Indies, so that she might avoid the fate that otherwise would be hers under his terrible edict that none of his brides should live longer than one day and published, it is thought, in Cairo about the end of the 14th century, we read of marjoram, pepper, cinnamon, onion and sesame. Marjoram growing on the banks of a river diffusing its delightful fragrance; onions for sauce, "cook this nicely with onion-sauce and spices"; cinnamon and pepper received in exchange for the coconuts of Sinbad the Sailor; and sesame for the magic call "Open Sesame" to which the door of the cave opened to admit the forty thieves.

The romance of the spices in the Middle Ages reached into the works of William Shakespeare (1564—1616):

I must have saffron to colour the warden pies; mace—dates,—none; that's out of my note; nutmegs, seven; a race or two of ginger,—but that I may beg; four pounds of prunes, and as many raisins o' th' sun.
—The Winter's Tale. iv. 2.

For you there's rosemary and rue; these keep
Seeming and savour all the winter long;
—The Winter's Tale. iv. 3.

Here's flowers for you;
Hot lavender, mints, savory, marjoram;
—The Winter's Tale. iv. 3.

The armipotent Mars, of lances the almighty,
Gave Hector a gift,—
A gilt nutmeg.
A lemon.
Stuck with cloves.
—Love's Labour's Lost. v. 1.

He's of the colour of nutmeg.
And of the heat of ginger.
—King Henry V. iii. 6.

Nay, you shall see mine orchard, where, in an arbour, we will eat a last year's pippin of mine own graffing, with a dish of caraways, and so forth:
—2 Henry IV. v. 3.

And, most dear actors, eat no onions nor garlick; for we are to utter sweet breath;
—A Midsummer Night's Dream. iv. 2.

I know a bank whereon the wild thyme blows.
—A Midsummer Night's Dream. ii. 2.

There's rosemary, that's for remembrance; pray, love, remember:
—Hamlet. iv. 5.

There's fennel for you, and columbines:—there's rue for you; and here's some for me:—we may call it herb-grace o' Sundays:
—Hamlet. iv. 5.

Doth not rosemary and Romeo begin with a letter?
—Romeo and Juliet. ii. 4.

These,* and more.

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* *The Complete Works of William Shakespeare*, Books, Inc. New York. 1946.

IX. THE PORTUGUESE SEEK THE SPICE LANDS

IN the 15th century, the spice trade of the East and Middle East was dominated by Moslem merchants. Their Eastern pivotal points were Calicut, Colombo, and Malacca. In the Middle East, their greatest markets were Constantinople and Alexandria. Spices bound for Constantinople from India and the Far East went by way of the island of Hormuz in the Persian Gulf; those for Alexandria by way of the Red Sea and the ancient city of Mecca. In the Mediterranean, the Venetians were the undisputed masters of the spice traffic moving between Middle East centres and European points.

The Middle Ages had witnessed the steady rise of Venice in commercial and maritime importance. From her favorable situation at the head of the Adriatic, between East and West, she had been of strategic importance in the affairs of many nations, and had fattened on the territorial and trading concessions which she had exacted as her reward. Her merchants and bankers were in every sizable port in the Mediterranean and the Middle East, from her own great city and the ancient port of Alexandria to the glittering city of Constantinople. Genoa had battled her only to be defeated at Chiogga in 1380 and to lose what she had attained as a maritime power. Venice was predominant, absolute controller of the Mediterranean trade and she was detested by the powers of western Europe.

But the light of the renaissance was now shining in the dark places of the world. A renewed interest in art, literature, politics, religion, education, and science was sweeping all Europe. From her wealth, accumulated in the spice and other trade with the Orient, Venice had contributed no small part to the renaissance, particularly in the arts, but Venice was to suffer, not to gain, from this great rebirth of learning. With the conquest of Constantinople by the Ottoman Turks in 1453, the troubles of Venice began; long wars with the Turks hastened her decay. Any hope that she might have had that her commercial prosperity would survive these trying and exhausting times was dashed to pieces in the year 1487 when Bartholomew Diaz discovered the

Cape of Good Hope. This was surely her darkest hour. The princes and navigators of western Europe were now as much awake as the renaissance itself and no longer would merchants pay tribute to Venice for the oriental spices which they found so useful and which they needed so badly.

And the man directly responsible for the success of Bartholomew Diaz was Prince Henry the Navigator.

Henry of Portugal, surnamed the "Navigator," duke of Viseu, governor of the Algarve, was born at Oporto on March 4, 1394. He was the third surviving son of John I of Portugal. His mother was Philippa, daughter of John of Gaunt, Duke of Lancaster, fourth son of Edward III. Prince Henry never went to sea himself, but devoted his life to the cause of navigation and maritime exploration. At Sagres, in 1418, he established an observatory and school of navigation and throughout the years of his useful life, he gathered about him the leading astronomers, geographers, cartographers, and navigators of the time.

Prince Henry had the conviction that India could be reached by sailing south along the west coast of Africa. Men as competent and informed as he and his colleagues would know of the Phoenician circumnavigation of Africa over two thousand years before, and they would have little doubt about the world being round. If India could be reached by an all-sea route, the power of Venice would be broken, the Moslems could be attacked and swept from the seas, and the spices of the Malabar coast of India, Ceylon, and the East Indies would fall into the hands of Portugal. To Lisbon would come all the spices of the Orient and the great wealth of this trade would enrich the coffers of the king, fatten the merchants, and bring prosperity to all the people of Portugal.

Under the impetus of Prince Henry, the learned advisers worked out detail after detail, made better charts, plotted new courses, and perfected the instruments of navigation. Shipyards rang with the sound of singing saws and clanging hammers as timbers were cut, shaped, and nailed to fast-growing caravels by busy, sweating shipwrights. As fast as the little ships left the ways, they were equipped and stored and then manned by stout-hearted sailors and commanders who did not hesitate to sail them into unknown deeps. By 1460, Porto Santo, Madiera, islands in the Azores, Cape Bojador, Cape Blanco, Senegal, Cape Verde, and Cape Verde Islands had been discovered or rediscovered.

In that year, Prince Henry died. He had not seen his dream come true, but the great work of exploration which he had started was soon to bring honor and everlasting credit to his name.

In 1471, the equator was crossed. In 1482, the Congo was reached. And in 1487, Bartholomew Diaz doubled the Cape of Good Hope, proving the Indian Ocean was accessible by sea and justifying all the efforts of Prince Henry the Navigator.

During the years that the Portuguese mariners were pushing their way south along the west coast of Africa from the Congo to the Cape of Good Hope, King John II of Portugal sent expeditions overland to discover the countries where the spices grew. The most notable mission was that of Pedro de Covilham. He left Lisbon in 1487 and went east by way of Barcelona, Naples, Cairo, and Aden. At Aden, he embarked on a Moslem ship and crossed the Arabian sea to Cannanore, from where he went to Calicut. In Calicut, he saw large quantities of pepper and ginger and heard that other spices were brought there from more distant places. From Calicut he went to Goa and then to the island of Hormuz in the Persian Gulf, where he saw a great trade in spices. Having noted carefully all he had seen and heard in India and at Hormuz, he returned to Cairo and sent a full report to Lisbon.

Enthusiasm was rife in Lisbon. The blaze of the spices was leading the Portuguese toward the dawn of their golden age. King Emanuel, called Great, Happy, and Fortunate, took up the torch when he came to the throne in 1495. The Cape of Good Hope had been doubled, and the sea route to India must now be found. He turned to Vasco da Gama. This dauntless mariner was born in 1460, the year in which Prince Henry died—destiny bringing to the world the man who would finish the work the Prince had started. Born at Sines, a small seaport in the province of Alemtejo, Portugal, da Gama had the smell of the sea in his nostrils. He early gained distinction as an intrepid mariner and skilled navigator, and he was only thirty-six years old when appointed to the command of the expedition which was to bring the spices of India direct to Portugal.

Vasco da Gama sailed in July 1497, with three small ships, none above 120 tons' burden. He sailed south to the Canaries and Cape Verde Islands and then followed an open ocean course southward which cut out miles of coasting and brought him to the Cape of Good Hope. He was evidently quite sure of himself, for after more than 4,000 miles of deep-sea sailing, he arrived at St. Helena bay, less than 200 miles coasting distance from the Cape. Ouite an accomplishment in those days. He rounded the Cape of Good Hope, and worked his way along the African coast north to Mozambique, Mombasa and Malindi. At Mozambique, he saw Arabian boats loaded with cloves, ginger and pepper, but the Christian-hating Moslems would give him neither information nor aid. His reception at Mombasa was equally unfriendly, but at Malindi, 200 miles north of zanzibar, his reception was favorable and he obtained provisions and a pilot competent to guide his little fleet to India.

Departing from Malindi on April 24, 1498, da Gama ran a splendid passage, speeded along by the southwest monsoon, and sighted land not far from Calicut twenty-three days later. On May 20, he anchored within a few miles of Calicut harbor. The Hindu prince of Calicut, known as the Zamorin, was not unfriendly, but the Arabian traders looked on the Portuguese with suspicion and hatred. Vasco da Gama had frankly said that he had come in search of spices, but the Moslem traders wanted no Christian interference in their affairs and saw to it that he obtained little cargo. However, Vasco da Gama and his valiant men had been the first Europeans to reach India by an all-water route: the hopes of Prince Henry the Navigator had been fulfilled and this was reward enough. Actually, they were overjoyed: they had found Calicut the centre of a region producing cinnamon, ginger, and pepper and, like Covilham before them, learned that many other aromatic and pungent spices came to this port from more distant spice lands. This voyage was going to make great news in the court of Emanuel!

Vasco da Gama sailed from Calicut and, after making a call at Cannanore, set out on his return voyage to Portugal. On the way to Africa, many of his men died from scurvy, the terrible scourge of the seas in those days and one vessel was destroyed. The run home from the Cape of Good Hope was uneventful and, in August 1499, Vasco da Gama ended his historic voyage in the port of Lisbon.

Vasco da Gama and his men were welcomed with great rejoicing and festivity. He was able to confirm in the presence of Emanuel all that Covilham had reported and he proudly told of what he had seen and heard in Calicut. He spoke of the cinnamon, ginger, and pepper of southern India and of the costly spices that came to Calicut from the eastern islands. King Emanuel was delighted. All Portugal was glad.

When the news reached Venice, that city was shocked. Following on the discovery of Diaz, this voyage of da Gama was a serious matter. The merchants and bankers of Venice knew only too well what this news meant. Following the conquest of Constantinople by the Turks, the Venetians had brought their spices from the east by way of Egypt. Thus the news of the Portuguese success was equally shocking to the Egyptians. For the Sultan of Egypt, it meant the loss of the large revenue which he obtained from the movement of spices through his kingdom. Altogether, it was a bad day for the merchants and princes of Venice and the Middle East: Spices were making history!

X. CHRISTOPHER COLUMBUS SAILS WEST TO FIND THE SPICE LANDS

PAOLO DEL POZZO TOSCANELLI, physician and amateur cosmographer of Florence, wrote in a letter to Christopher Columbus:

> I observe thy great and noble ambition to pass over to where the spices grow.*

About the time that the exploration ships of Prince Henry the Navigator were pushing southward along the African coast just beyond Cape Verde, there was born at Genoa, Italy, of humble family, one whose thoughtful eyes were to watch in later years the accomplishments of the Portuguese navigators, while his strong mind formulated plans destined to carry him beyond the achievements of any mariner of his time and to write his name large in the pages of history.

Christopher Columbus, it is now generally believed, was born in the year 1451. The day and month of his birth are not definitely known and information about his early life and training is incomplete and uncertain. Details of his education are lacking. His son, Ferdinand, claimed that Columbus attended the University of Pavia and studied geometry, astronomy, and cosmography. But it is also said that Columbus went to sea at an early age and subsequently educated himself in these and other subjects. At Lisbon, in 1478 or 1479, he married Felipa, daughter of Bartholomew Perestrello, who had been governor of the Portuguese island of Porto Santo from 1425 until his death about 1457. From his mother-in-law, Columbus is supposed to have received Perestrello's charts and writings, which enabled him to acquire useful data on the voyages of the Portuguese, who, by this time, had crossed the equator in their push south along the west coast of Africa, and were approaching the Congo.

Columbus was fully aware that the Portuguese were on the trail of the spices and he was every bit as keen as they to reach the lands where the spices grew. The Portuguese were making good progress, but to his way of thinking, they were going in the wrong direction—or, if a road to the East was possible by first sailing south, they were taking the longest course. From his own investigations and from the information gained in numerous talks with mariners and scholars, Columbus had reached the conclusion that, if he were to sail westward and not southward as the Portuguese, he would come to the rich spice-bearing lands of the Orient by a much shorter and faster route. According to the geographical knowledge of his day, such a route would appear quite possible to him. He may even have studied the words of Strabo, who 1500 years before Columbus, said:

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* *Admiral of the Ocean Sea*, page 63.

> If the extent of the Atlantic was not an obstacle, we might easily pass by sea from Iberia [Spain] to India still keeping the same parallel.

Columbus was obsessed with the idea and all that remained was to find sponsors and financial backing for the undertaking. This was the most difficult part of his task and probably the most disappointing. He approached the king of Portugal, but that monarch was not greatly interested in his plans. In 1485, Columbus went to Spain.

Christopher Columbus saw Ferdinand and Isabella for the first time in the spring of 1486, but they gave little credit to his ideas. That the most treasured of all spices came from the Orient was not in question and it was true that Marco Polo had spoken of islands in an eastern sea where "pepper, nutmegs... and all the other valuable spices" grew in abundance. This was as well known to Spain as it was to Portugal or any other European country. But the plan to discover a sea route to the Eastern spice lands by sailing westward doubtless sounded fantastic. Their Majesties were unconvinced, but nevertheless turned the proposition over to a committee of experts for investigation. Some four years later, the Spanish monarchs were advised against the undertaking, and since they were occupied at that time with matters much more important to them, Columbus was dismissed for the time being. Meantime, his brother, Bartholomew, had laid the plan before Henry VII of England, and then Charles VIII of France, but without success.

It was a very difficult time for Columbus, faced as he was with the prejudice, intolerance, and scorn of Spanish courtiers and the tiresome opposing arguments of Their Majesties' learned counsellors. However, Columbus was not without influential friends at the Spanish court and one of these finally succeeded in convincing Queen Isabella that the proposed enterprise was practicable and worth attempting. In April 1492, the Articles of Agreement were drawn up: Columbus was to discover certain islands and mainland in the ocean sea and his reward was to be one-tenth of all spices, gold, gems, and other merchandise accruing from the venture, free of all taxes. In addition, he was to have the titles of Admiral and Viceroy and Governor of the lands discovered by him.

Three small ships, *Santa Maria*, *Pinta*, and *Nina*, manned with some ninety willing, but doubtful officers and men constituted the expedition and, on August 3, 1492, with Christopher Columbus on board *Santa Maria*, the little fleet sailed out of the harbor of Palos into the unknown wastes of the great Atlantic ocean. In search of the spice lands of the Orient and sustained by a great conviction, Columbus turned his face to the West and looked confidently into the future.

After a short stop at the Canary Islands, Columbus set a westward course, and his first history-making voyage began. His men were not all as stout-hearted and strong-willed as he and, with the passing days and weeks, they became very restless. They were alarmed by magnetic variation which they did not understand, afraid when a meteor seemed to fall into the sea just 16 or 20 miles away from them, uneasy about the floating mats of weeds which swept by their ships, and depressed from long weeks at sea. Weary for the sight of land and worried, as some of them must have been, that at any minute they might sail over the edge of the flat earth and disappear into unending space, their thoughts ran all the way from childlike fear to near mutiny. But Columbus held to his objective and in the darkness of the night of October 11th, a light was seen. Sixty-nine days out of Spain and land at last. But what land? Had Columbus reached the coast of Asia as he hoped and expected? Was he about to smell the sweet aroma of oriental spices?

Next day, Columbus went on shore. It was not mainland, but an island. Perhaps one of the spice islands! Columbus looked about him: the scene was beautiful and the vegetation was so bright and green. But he found no spices on this little island, nor any other of the treasures of the Orient to cheer his mighty heart. Yet he was sure this was one of the islands of the Eastern Sea, and that farther on he would find the spices he sought. He called the island San Salvador. You will find it on the map as Watling Island.

Leaving San Salvador, Columbus next discovered the islands of Santa Maria de la Concepcion (Rum Cay), Fernandina (Long Island), and the island of Isabella (Crooked Island). He found these islands to be beautiful, but as destitute of the spices of the Orient as San Salvador itself. At Isabella, Columbus notes in his *Journal:*

> ...we ran along the coast of the island, westward from the islet, and found its length to be 12 leagues as far as a cape, which I named Cabo Hermoso [Cape Beautiful], at the western end. The island is beautiful,...I believe that there are many herbs and

> many trees that are worth much in Europe for dyes and for medicines; but I do not know them, and this causes me great sorrow.*

Bright vegetation and beautiful trees and, for all he knew, bearing the spices he longed to find, but he could not be sure for he was not skilled in the knowledge of plants and could not recognize them! Columbus was often in this situation and apparently, his staff did not include a botanist or one trained in plant identification. Continuing, he says:

> Arriving at this cape, I found the smell of the trees and flowers so delicious that it seemed the pleasantest thing in the world....This cape, to which I gave the name of Cabo Hermoso, is, I believe, on an island separated from Isabella, and there is another small islet between them. [Cape Hermoso is on Fortune Island.] I did not try to examine them in detail, because it could not be done in 50 years. For my desire is to see and discover as much as I can before returning to your Highnesses, our Lord willing, in April. It is true that in the event of finding places where there is gold or spices in quantity I should stop until I had collected as much as I could. I, therefore, proceed in the hope of coming across such places.**

Of another part of the Island of Isabella, he says:

> There are trees of a thousand sorts, and all have their several fruits; and I feel the most unhappy man in the world not to know them, for I am well assured they are valuable.†

Here, the natives told Columbus about a large island which they called Cuba lying to the west-southwest, abundant with spices and where there were many big ships, numerous merchants, and great trade. Spurred by this information, the three ships weighed anchor midnight October 23rd and Columbus happily set out on the course given him. He was now doubly sure that he was in Eastern waters and at last bound for some part of the rich Asiatic world which he had read about in his *Marco Polo*. On October 23rd, before leaving the Island of Isabella, he wrote in his *Journal:*

> I desired to set out today for the island of Cuba, which I think must be Cipangu, according to the signs these people make, indicative of its size and riches,...It is better to go where there is great entertainment, so I say that it is not reasonable to wait, but rather to continue the voyage and inspect much land, until some very profitable country is reached, my belief being that it will be rich in spices. That I have no knowledge of these products causes me the greatest sorrow in the world, for I see a thousand kinds of trees, each one with its own special truit, as well as a thousand kinds of herbs with their flowers; yet I know none of them...††

This leaves little doubt as to where Columbus thought he was, and what he was seeking.

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* *The Northmen Columbus and Cabot*, page 123.

** *Ibid.*, page 124.

† *Ibid.*, page 125.

†† *The Northmen Columbus and Cabot*, pages 127, 128.

At the island of Cuba, which he later concluded was not Cipangu (Japan), but Cathay, the search for spices was continued.

> After a time, Martin Alonso Pinzon came to him [Columbus] with two pieces of cinnamon, and said that a Portuguese, who was one of his crew, had seen an Indian carrying two large bundles of it; but he had not bartered for it, because of the penalty imposed by the Admiral on any one who bartered. He further said that this Indian carried some brown things like nutmegs. The Admiral went to the place, and found that they were not cinnamon trees.*

Very disappointing! This bark would be that of *Canella winterana* (Linne), commonly called white cinnamon. It is a native of those parts, and has a slight aromatic odor resembling that of the true cinnamon bark.

> The Admiral showed the Indians some specimens of cinnamon and pepper he had brought from Castile, and they knew it, and said, by signs, that there was plenty in the vicinity, pointing to the S.E.†

Well, that was good news, and so on November 6th, Columbus "prepared to depart on Thursday, in the name of God, and to steer S.E. in search of gold and spices, and to discover land."††

Altogether, Columbus tarried about a month on the Cuban coast, carefully exploring bays and rivers, but he found no spices other than the supposed cinnamon mentioned already and some of the hot capsicum peppers commonly used by the natives. Nor did he find any activities resembling those of a prosperous eastern empire, but he held to his conclusions that he was in eastern waters and although he was without proof, he was sure these lands contained "an infinity of spices." Columbus explored the Cuban coast to about the 78th meridian and then put his helm about and worked in an easterly direction beyond Cuba to the island of Hispaniola.

Christopher Columbus was an enthusiastic soul and always the optimist. At Hispaniola, where he first anchored on December 6th, and which island he later insisted was Japan ("The Admiral concluded that Cipangu was in that island, and that it contained much gold, spices, mastic, and rhubarb"), he found a rich flora of tropical beauty exceeding that of Cuba, "so that the Admiral thought there must be nutmegs and other spices among them, but he did not know them, and they were not ripe." He named the harbor where he had anchored, in honor of the patron saint of children:

> At the hour of vespers the Admiral reached this port, to which he gave the name of Puerto de San Nicolas, in honor of St. Nicholas, whose day it was.

Farther along the coast, on December 25th, *Santa Maria* ran ashore and became a total wreck. He named the place of this disaster Puerto de la

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* *The Northmen, Columbus and Cabot,* page 138.

† *Ibid.*, page 138.

†† *Ibid.*, page 143.

Navidad. And here he built a fort with timbers and other materials salvaged from the wreck and garrisoned it with some forty men whom he instructed to spend their time during his absence looking for spices and gold:

> He trusted in God that, when he returned from Spain, according to his intention,... they would have found the mine and spices in such quantities that the Sovereigns would, in three years, be able to undertake and fit out an expedition to go and conquer the Holy Sepulchre.

Columbus speaks in his Journal of the extensive supply of spices in these parts: "The supply of spices also is extensive, and is worth more than pepper or manegueta [Grains of Paradise]." And, "the people ought to be treated with honor and favor, seeing that this island has so much gold and such good spice-yielding lands." And again, "there is also plenty of aji, which is their pepper, which is more valuable than pepper, and all the people eat nothing else, it being very wholesome." How anxious he was to have their Highnesses believe that these were indeed the Eastern spice islands!

Santa Maria lost and *Pinta* having "parted company" somewhere along the Cuban coast, Columbus began his homeward voyage aboard his remaining ship *Nina* on January 4, 1493. From La Navidad, he coasted easterly as far as Samana Bay and left Hispaniola behind on January 16th. On the Atlantic crossing, Columbus enjoyed excellent weather until February 12th when he ran into very heavy seas. He arrived at the island of Santa Maria in the Azores on February 17th and there experienced some difficulties with the Portuguese. On March 4th, he anchored off Restelo, near Lisbon, having been forced to enter the Tagus by stress of weather. And on March 15th, he crossed the bar of Saltes and anchored off the harbor of Palos, his famed voyage ended. The people of Palos were lavish in their welcome and at Barcelona, Columbus was the hero of the hour as he made his way through crowded streets to be joyfully received by Ferdinand and Isabella in all the glitter and splendor of full court.

Actually, Columbus did not know what lands he had discovered, but he felt very sure they were those of China and Japan and the islands lying off those countries. How he accounted to the King and Queen for his lack of spices, we do not know. To be sure, he would exhibit his specimens of so-called cinnamon and the native capsicum pepper, but these would hardly convince their Highnesses that he had discovered the rich spice lands which Marco Polo had said existed in the Eastern Sea. However, he had accomplished a great deal and we suppose he easily persuaded Ferdinand and Isabella that he would return from a subsequent voyage with rich cargo of aromatic and and pungent oriental spices.

Christopher Columbus now enjoyed the full confidence of Ferdinand and Isabella. He had sailed west and planted the Spanish flag on virgin soil, adding new territory and prestige to the Spanish crown; another voyage to the New World would bring the wealth of these distant lands to Spain.

Three great carracks and fourteen caravels were made ready for sea, stored, and manned with 1200 officers and men and on September 25, 1493, Admiral Columbus, Viceroy and Governor of the new lands across the sea, proudly sailed from the port of Cadiz.

After an uneventful run across the Western Ocean, Columbus sighted land on November 3rd—an island which he named Dominica. He was in the Leeward Islands. On the island of Marie Galente, he found a tree whose leaves gave off the fragrant aroma of cloves. Dr. Chanca, a physician of Seville and a member of this expedition, said in a letter to the Town Council of Seville:

> We found there a tree whose leaf had the finest smell of cloves that I ever met with; it was like a laurel leaf, but not so large: but I think it a species of laurel.

There can be little doubt that the tree they found was a species of the genus *Pimenta*, native to the West Indies and adjoining mainland of Central America and belonging to the same family as the clove. It was, most likely *Pimenta racemosa*, common to the Leeward and Virgin Islands, but it may have been *Pimenta officinalis* or allspice, which is much more abundant in the island of Jamaica. Being November, the tree would not be in fruit, and this is probably the reason why a conclusion was reached so quickly and the tree so promptly forgotten.

If the tree they found was an allspice tree, this would be the first European contact with a tree whose fruit has been one of the most desirable of all aromatic and pungent spices for over 300 years. Columbus was so eager to find spices that it is difficult to believe that the abundant allspice of Jamaica should have escaped his notice when he reached that island later in his explorations, yet this seems to be the case. It is understood that this spice was unknown to Europeans in Columbus's day and that Columbus could not inquire about a spice which to him did not exist, but had he found the natives using this spice or had he gathered it from the allspice trees of Jamaica, he would most certainly have carried it back to Europe as a new spice or, because he had "no knowledge of these products," as a species of clove since its aroma is similar to that of the clove. In the face of his repeated references to his lack of knowledge of plants, and spice plants in particular, it would not have been an unreasonable mistake for him to have made. Later Spanish explorers were perhaps not better informed and they found the spice, but apparently thought it was a species of pepper and called it Pimienta, which accounts for its botanical name, *Pimenta officinalis*, and its other common names, pimento, Jamaica pepper, and clove pepper.

On the island of Guadeloupe, Columbus found unmistakable signs of cannibalism. Wrote Dr. Chanca: "In one of the houses we found the neck of a man cooking in a pot."

From Guadeloupe, the fleet followed the Leeward Islands northward, passed in sight of the Virgin Islands, sailed south of Puerto Rico, reached the island of Hispaniola, and finally came to Puerto de la Navidad. Here, Columbus expected to find the fort he had established a year ago, but nothing remained of it except a few burnt timbers, and of the men only some clothes "lying upon the grass" to mark their tragic end. For some reason or other, the garrison had aroused the resentment of the natives who had risen and murdered them all. The Admiral left this scene of desolation and followed the coast in an easterly direction until he found a suitable place to build another fort and start a new settlement. He called the new site Isabella, after the queen.

Dr. Chanca, describing this district, says in part:

> We found other trees which I think bear nutmegs, because the bark tastes and smells like that spice, but at present there is no fruit on them; I saw one root of ginger, which an Indian wore hanging round his neck....A sort of cinnamon also has been found; but, to tell the truth, it is not so fine as that with which we are already acquainted in Spain. I do not know whether this arises from ignorance of the proper season to gather it, or whether the soil does not produce better.*

So pitifully anxious was Columbus to find spices, that even this learned member of his staff saw, or imagined he saw, supposed, suspicioned, and excused spices which did not exist in those islands at that time.

> Further on, speaking of the food of the natives, the doctor says:
>
> Their food consists of bread, made of the roots of a vegetable which is between a tree and a vegetable, and the *age*, which I have already described as being like the turnip, and very good food; they use, to season it, a spice called *agi*, which they also eat with fish, and such birds as they can catch of the many kinds which abound in the island. They have, besides, a kind of grain like hazel-nuts, very good to eat. They eat all the snakes, and lizards, and spiders, and worms, that they find upon the ground; so that, to my fancy, their bestiality is greater than that of any beast upon the face of the earth.**

The *agi* noted here is the hot capsicum pepper which, as previously observed, was commonly employed by the natives of the West Indies.

In due course, Columbus embarked upon further exploration of the Indies. He sailed for Cuba, followed the Cuban coast toward Cape Cruz, then steer-ing southward discovered the island of Jamaica, May 5, 1494. He entered St. Ann's Bay and marvelling at the great beauty of the place named the harbor Santa Gloria. From Jamaica, he returned to Cuba and explored the southern coast, sailing westerly beyond the Isle of Pines perhaps as far as Cortes Bay. He then returned to Jamaica and explored the southern coast of that island to Morant Point and from here sailed south of Hispaniola and through the Mona Passage to his new settlement at Isabela, arriving September 29th. Columbus remained at Isabela until March 10, 1496, when he sailed for Spain, arriving at Cadiz, June 11th.

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* *The Northmen, Columbus and Cabot*, page 311.

** *Ibid.*, pages 311, 312.

On his second voyage, Christopher Columbus had found new lands and a small quantity of gold, but the aromatic and pungent spices of the East he had not found. Some of the so-called cinnamon, which European merchants of the time said tasted "like bad ginger," and a quantity of acrid capsicum peppers which lacked the "flavor of that of the Levant," were shipped to Spain when Columbus dispatched twelve of the ships home under Antonio de Torres in February 1494. This, apparently, was the extent of the spice trading accomplished on this second expedition to the West Indies.

Firm in his conviction that the lands he had discovered were in truth those of the Orient, Columbus prevailed on Ferdinand and Isabella to authorize a third voyage to the West for the purpose of finding a great mainland lying beyond and south of the places he had already reached. He sailed from Spain in command of six vessels on May 30, 1498 and steered for the Canary Islands from where he dispatched three of his ships directly west to Hispaniola. With the remaining three ships, he sailed south to the Cape Verde Islands and then altered course to the west. The voyage across the Atlantic was painfully slow and at times the tropical heat was most exhausting. Las Casas in his *History* tells us:

> And he [Columbus] says that there, Friday, July 13, the wind deserted him and he entered into heat so great and so ardent that he feared the ships would take fire and the people perish. The ceasing of the wind and coming of the excessive and consuming heat was so unexpected and sudden that there was no person who dared to descend below to care for the butts of wine and water, which swelled, breaking the hoops of the casks; the wheat burned like fire; the pork and salted meat roasted and putrefied. This ardent heat lasted eight days.*

It was with great relief that the fleet received the signal from the Admiral's ship when on July 31st his lookout saw the peaks of Trinidad. On August 1st, the mainland of South America was sighted, but Columbus concluded it was just another island. Coasting the shores of Trinidad the fleet passed through the Serpent's Mouth into the Gulf of Paria. After some exploration here, Columbus took his ships through the Dragon's Mouth into the Caribbean Sea, sailed westward off the Paria coast, passed the island of Margarita as he headed northwest, and arrived at Santo Domingo, Hispaniola, on August 31st. He had sailed along the shores of the continent he sought, but believed it was an island. It was not until he had left the coast of South America and was bound for Hispaniola that he concluded the great land mass which he had left behind was not an island but a continent.

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* *The Northmen, Columbus and Cabot,* pages 327, 328.

Two years later, one Francisco de Bobadilla arrived at Santo Domingo armed with administrative and judicial powers by Ferdinand and Isabella. Apparently, the King and Queen were uneasy about the government of Hispaniola under Columbus and were aroused by stories of cruel and oppressive methods allegedly used by him against the Indians. The overzealous Bobadilla made Columbus a prisoner, clamped him in chains, and shipped him off to Spain under escort much to the annoyance of Queen Isabella who, hearing about the matter on his arrival in Cadiz, ordered his immediate release and gave instructions that the Admiral should be sent to the court in all honor.

Columbus successfully defended himself and even persuaded the Sovereigns to permit him to undertake yet another voyage to the West, this time to find a strait or passage through the southern land mass he had seen on his third voyage. This passage, he was sure, should lead him to the great spice lands of the Grand Khan. Said Las Casas: "For he always was of opinion that ...if he were to find a sea passage, he would find people of the Grand Khan." Cautioned to pay special attention to spiceries, amongst other products of the East, Columbus sailed from the port of Cadiz, May 9, 1502, with four caravels and 140 men, on his fourth and last voyage across the North Atlantic.

The island of Martinique was reached June 15th and Jamaica, on July 14th. Columbus did not stop at Jamaica but passed south of this island and was carried by a "strong current" to the Queen's Garden, a group of islands lying south of Cuba, and so named by him in 1494. Sailing south from these Cuban islands, he next arrived at the small island of Bonacca, lying some 25 nautical miles north of Cape Honduras. Here Columbus encountered an Indian canoe, apparently occupied in trade between Bonacca and the mainland, whose elderly chief he made captive, presumably for the old man's local knowledge and his future use as an interpreter. From his prisoner, Columbus gathered that he was very close to a large and luxuriant country. We can imagine the effect of this knowledge on Columbus. A new light would come into his now weary eyes, his thoughts would race, and his voice would rise as he impatiently demanded more information in a tongue which the confused Indian would not understand. Then he would turn away from the old man and look across the water at the distant shore, wondering if at last he had reached the empire of the Grand Khan, or India, or perhaps the great spice island of Java which he had read about in his *Marco Polo*. Surely, he would think to himself, it must be so—had he not all this time been in the Eastern Sea sailing among the "seven thousand four hundred islands" of Marco Polo? And if this land was but part of the mass he had seen at Paria on his third voyage, then here must be the passage that should lead him to his goal. Was he at last to be rewarded with an abundance of costly spices and other rare treasures of the Orient?

Columbus reached the mainland of Honduras in the vicinity of Trujillo, and then coasted eastward. He battled terrific winds and seas on the run to Cape Gracias a Dios, sailed south in fair weather along the Nicaraguan coast, and rested at a suitable harbor somewhere on the coast of Costa Rica:

> I reached the land of Cariay where I stopped to repair my vessels and take on provisions, as well as to afford relaxation to the men, who had become very weak.

From here he sailed to Almirante Bay and Chiriqui Lagoon which lie together in what was then the province of Veragua, and which he thought was the province of Ciamba, the Ziamba of Marco Polo; said Marco Polo: "Upon leaving Zaitun...you arrive at a country named Ziamba," and "departing from Ziamba...you reach an island of very great size named Java." In other words, Columbus thought he was on the coast of Cochin-China. His painstaking examination of the coast had failed to yield the strait he sought and, doubtless, by now his men were restless, sullen, and resentful, asking only that Columbus give up his searching and turn the prows of his little fleet to the north.

At Chiriqui Lagoon, Columbus heard about a province which the Indians called Ciguare:

> Nine days journey across the country westward: they tell us there is a great quantity of gold there,...they [the people of Ciguare] are likewise acquainted with the pepper-plant,... they also say that the sea surrounds Ciguare, and that at ten day's journey from thence is the river Ganges,...these lands appear to hold the same relation to Veragua [where he was] as Fortosa to Fontarabia, or Pisa to Venice.

From this it would appear that Columbus now realized he was standing on an isthmus, and that the province of Ciguare, on the Pacific side, rather than Veragua, was the Ziamba of Marco Polo. And one would expect that his search for a strait would have been intensified since he would know that Marco Polo had sailed along the coast of Ziamba on his voyage from Zaitun, China, to Persia by way of the Malacca Strait and Cape Comorin, India. But whether because of his confused geographical situation, the condition of his ships and men, or the lure of gold which the Indians had told him he would find farther on, the quest for the strait seems to have been abandoned.

He left Chiriqui Lagoon on October 17th and spent eleven and a half weeks battling the elements and looking for gold along the coast of Panama, sailing easterly and then westerly.

> On the day of Epiphany, I reached Veragua in a state of exhaustion; there, by our Lord's goodness, I found a river and a safe harbor.

It was January 6, 1503, and he was at Belen. Here he established a settlement, and here he met with considerable misfortune. Heavy rains flooded the river and the rush of water carried one of his ships against another, causing damage and nearly resulting in the loss of both; trouble with the Indians brought death to a number of his men; and one of his ships had to be abandoned.

Columbus sailed from Belen on April 16th with his remaining three ships, "rotten, worm-eaten and full of holes," and made Porto Bello on April 23rd where another ship was given up:

> I then had only two left, and they in the same state as the others. I was without boats and provisions, and in this condition I had to cross seven thousand miles of sea; or, as an alternative, to die on the passage with my son, my brother, and so many of my people. Let those who are accustomed to finding fault and censuring ask, while they sit in security of home, "why did you not do so and so under such conditions?" I wish they now had this voyage to make.*

From Porto Bello he coasted easterly for a while and then struck out for Cuba, and "on the thirteenth of May I reached the province of Mago, which borders on Cathay." From Cuba he sailed to St. Ann's Bay, Jamaica, where the two ships were beached June 25th because their crews could no longer keep them afloat.

Columbus remained in Jamaica for one year, and on June 29, 1504, he departed aboard a rescue ship for Santo Domingo from where he sailed for Spain, September 12th, and arrived at Sanlucar de Barrameda on November 7th. He was a very sick and unhappy man. There was no court reception for him this time and on November 26th, Queen Isabella, who had so warmly befriended him, died. Columbus was carried to his home in Seville and died at Valladolid, May 20, 1506.

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* *The Northmen, Columbus, and Cabot,* page 405.

He had not reached the glittering courts of Eastern empires, nor smelled the fragrance of the spices which grew on the tropical isles of the Eastern Sea. For him, there had been no aromatic and pungent cloves, ginger, nutmegs, or mace; no fragrant cinnamon or cassia, not even a decent pepper! But the spices of the East Indies had led him to the West Indies, and to the land of America where his name is honored.

The discoveries of Christopher Columbus opened the West Indies to the trade and commerce of the world and it was not long before the spices of the East were introduced into the West. Today, the world's finest ginger comes from Jamaica and the nutmegs and mace of Grenada are exported to all parts of America and Europe. The capsicum spices of the New World were introduced into the Old World, and today these useful peppers are cultivated in many parts of Europe, in Africa, India, East Indies, Japan, and other distant lands.

XI. JOHN CABOT SAILS WEST IN SEARCH OF SPICES

THERE can be little doubt that to sail by the shortest route to the lands where the costly aromatic and pungent spices grow was the prime objective of Christopher Columbus. All Europe sought the cassia, cinnamon, ginger, mace, nutmeg and pepper of the Orient and there was wealth and honor awaiting the navigator who first brought these spices directly from their native lands. The Portuguese were sailing south seeking an all-water route to India and the efforts of Columbus were clearly directed at reaching the spice lands ahead of them by following what he believed to be a much shorter route to the East. This same objective took John Cabot to the court of Henry VII and brought England into the race to reach the treasured spice lands.

John Cabot was born at Genoa in 1450. In 1476 he became a citizen of Venice. He was a skilled navigator and, in his Mediterranean voyages, undoubtedly carried many mats and bales of aromatic spices from Alexandria to Venice. Thus employed, he would soon realize the tremendous wealth accruing to Moslem and Christian merchants from the rich cargoes of spices coming to the Middle East from India and other parts of Asia. As a navigator, he had a good knowledge of the geography of his day and he was not one of those who believed the world was flat. Cabot is said to have visited Mecca "whither spices are brought by caravans from distant countries," where he asked the spice traders to tell him the name of the land or lands from whence the spices came. The wily merchants pretended not to know and told Cabot that they obtained the spices from other spice trading caravans which brought them from distant countries and that these traders, in turn, got them from still other spice merchants who brought them from remote regions. From this, Cabot is said to have concluded, "presupposing the rotundity of the earth," that the last merchants got the spices "at the North toward the West." In any case, Cabot saw cargoes of spices coming from the East to the Mediterranean and reasoned that, if the spices could come to the Mediterranean by way of the East, they could also come by way of the West because the world was round; therefore, if one sails west, one must come to the eastern spice lands.

John Cabot went to England and put these conclusions before Henry VII. If he were right, he argued, the spices of Asia could be brought by water directly to London and this would enrich His Majesty and bring great commercial prosperity to England. Henry was interested. Columbus had already completed two voyages to the West, but he had not yet found the spice lands. The Portuguese had doubled the Cape of Good Hope, but they had not yet found the water way to India; if there was anything to the ideas of Cabot, England might be yet the first to reach the famed spice lands of the East. Henry authorized an expedition without further delay and on May 2, 1497, John Cabot sailed from Bristol aboard the *Mathew* with eighteen men—a single little ship and a sparse crew: Henry was eager, but he wasn't risking much!

Cabot passed the western limits of Ireland, turned north, and sailed, as he thought, toward the oriental regions. The North Atlantic is a vast ocean; it can be peaceful under clear blue skies, but it can also be a raging hell of mountainous seas under black stormy clouds. This changeable mood of the Western Ocean and the usually prevailing westerly winds in those high latitudes would bring many anxious hours to Cabot and his men as their little ship, now heaving gently and barely moving, now storm tossed with shortened sails, fought her way through fifty-two days of sailing.

On June 24, 1497, John Cabot landed on the northern extremity of Cape Breton Island where he planted a large cross, the flag of England, and another of St. Mark and took possession of the land in the name of Henry VII of England. He was sure that he had reached the shore of Asia, but finding no Eastern people, he concluded that he had landed on an uninhabited part of the land of the Grand Khan. He put out to sea and continued his voyage of exploration. Perhaps he was looking for a passage that might permit him to sail farther into the heart of the great eastern empire, for he is said to have discovered other islands in the Gulf of St. Lawrence and to have made the mainland of North America (more than a year before Columbus sighted the South American mainland). But he saw no oriental cities, found no spices, and set sail for England with his mind made up to return and continue his search.

He arrived at Bristol after an uneventful voyage, August 6th, and reported that he had found, 700 leagues to the west, the great land of the Grand Khan. On his next voyage, he said, he would follow the coast southwards as far as Cipangu (Japan), "where he thinks all the spices of the world...originate."

The English merchants were well pleased with his account, and enthusiastic about the prospects of his next voyage. At London, he was warmly received by the king who rewarded him with a sum of £10, a pension of £20, and a promise that he should have a fleet of ten ships and all the convicts, except traitors, he needed for the voyage to Cipangu in the spring.

In the meantime, John Cabot visited Lisbon and Seville. At that time, the mariners of both these ports would be recounting the accomplishments of their navigators and truth and fable would be thoroughly mixed up, but there would be some information of value to Cabot on his forthcoming voyage. Portuguese navigators were putting thousands of miles behind them; Vasco da Gama had left on his momentous voyage to India about a month before Cabot arrived back in Bristol, and there might be new geographical information and perhaps some very late charts. In Seville there would be news of great interest to Cabot about the achievements of Columbus. In both these cities, John Cabot would spend hours in conversation with pilots, navigators, and others interested in shipping and maritime exploration, and he would listen intently to what they had to say. At Lisbon, he met a navigator called John Fernandes, known as Llavrador, from whom he obtained information about a great land lying to the north across the Western Ocean.

The following year, save in the number of ships, Henry VII kept his promise. In the month of May, 1498, with two ships and a complement of 300 officers and men, John Cabot sailed from Bristol fully confident that he would reach Japan and bring his ships home laden with the treasured spices of the East. Early in June he reached Greenland, the country that Fernandes had told him about in Lisbon, and he named it Labrador's Land in his honor.

Cabot followed the coast northward, looking for a passage through which he could sail to the spice lands, but, meeting with increasing cold and more and more icebergs, the crews of the two ships rebelled and he was forced to turn around and sail south. Rounding Cape Farewell, he sailed westerly to Baffin Land and believed that he had reached the coast of Asia. He now sailed south, as he said he would, to find Japan and the spices. He passed the Strait of Belle Isle, sailed down the Newfoundland coast, rounded Cape Race, and continued his exploration to latitude 38° N. In all this long distance, he met with not a single sign to confirm his belief that he was in the regions of the Grand Khan; no offshore breeze brought the fragrance of oriental spices to his nose. He could not find Japan. Thoroughly disillusioned, stores running short, crews in an ugly mood, Cabot gave up and sailed for home. He arrived in England in the autumn of 1498, and died before the year was out. Like Columbus, he had failed to bring the spices of the Orient to

Europe, but in seeking them, he had reached the shores of North America and written his name in the annals of maritime discovery.

John Cabot's first attempt to reach the oriental spice lands by sailing west across the Atlantic Ocean aroused considerable interest in Europe and was the subject of a letter, in August 1497, from one Lorenzo Pesqualigo to his brothers Alvise and Francesco, merchants of Venice, and of another, in December of the same year, from one Raimondo de Soncino to the Duke of Milan. It is from these letters that much of our information concerning John Cabot, his first voyage, and his intentions, is taken. The efforts of Cabot were also a subject of a dispatch under date July 25, 1498, to Ferdinand and Isabella of Spain from Pedro de Ayala, Junior Ambassador at the court of England. In this communication, de Ayala advises that Henry VII hoped to derive great advantage from the second voyage of Cabot and points out that he had advised the king it was his opinion that the land discovered by Cabot belonged to Spain "since it is, in fine, what fell to your Highnesses by the treaty with Portugal." He was referring to the Treaty of Tordesillas, June 7, 1494, about which we shall read farther on. The eye of Spain was fixed on the spice lands of the Orient, but it was the hand of Portugal that touched them.

XII. THE PORTUGUESE MASTER THE SPICE TRADE

IN the same month (May) that John Cabot set out so enthusiastically from Bristol on his second voyage to the west, Christopher Columbus sailed from Cadiz on his third voyage to the West Indies and Vasco da Gama arrived in Calicut, India. By the end of the same year (1498), Cabot had met with bitter disappointment and was dead, Columbus was in San Domingo and still searching for the eastern spice lands, and da Gama was homeward bound, the proud discoverer of the allwater route to India and the first western navigator to bring the pungent aromatics of the Malabar coast to Europe by way of the Cape of Good Hope.

To "sail by the west into the east where spices grow" was held entirely practicable by many European navigators in those days and the discoveries of Columbus and Cabot did not preclude the possibility of a passage to the east. There were those who held that such a passage was bound to exist to permit the waters to move freely about the globe under the influence of the heavens. Cabot had not found such a passage, and Columbus was still trying. As we shall see, the idea of sailing west to reach the eastern spice lands died hard. But the sagacious Portuguese had preferred to plan their undertaking in accordance with the known geographical facts of the day rather than risk time and money on expeditions into the unknown. Even if they had gone the longest way round to India (which they had not) they had got there, and this was the important thing. The course to follow now, they rightly decided, was to exploit their success to the utmost. They had reached India and if their great attainment was promptly followed up, they would soon capture the lucrative oriental spice trade from the Moslem merchants. They bitterly hated the Moslems and destroying the Moslem power and securing the immense wealth of the spices for themselves would be a twofold pleasure.

King Emmanuel immediately organized a large expedition to proceed at once over da Gama's route to the Malabar coast of India. He entrusted the command of the expedition to Pedro Alvares Cabral who, with thirteen ships and 1500 men, including 1200 soldiers, sailed from Lisbon on March 9, 1500. Cabral got as far as the Cape Verde Islands and then, for some unknown reason, his course changed to the southwest. Perhaps he was one of those who believed in the shorter route theory of sailing to the west to reach the "east where the spices grow" and was prepared to risk the attempt believing that if success should attend his venture, Emmanuel would be highly pleased and award him greater laurels than those gained by da Gama. And it may have been that he had no such ambitious intentions, but met with fierce gales which drove his fleet far to the west. In any case, he reached the shores of Brazil and took possession of the country in the name of King Emmanuel of Portugal.

Cabral dispatched one of his ships to Lisbon to advise the king of his discovery and then sailed for India by way of the Cape of Good Hope. Having arrived on the Malabar coast of India, Cabral visited Calicut, Cannanore, and Cochin and established Portuguese trading factories. The Malabar ports were under the rule of Hindu princes who were tolerant toward the zealous Christian Portuguese, but the Moslems who dominated the commercial affairs of the country hated the sight of the Portuguese. Under these circumstances Cabral had his difficulties and some fighting to do, but was able to carry out Emmanuel's wishes. The new spice trade was definitely under the control of King Emmanuel, and the factories were royal factories manned by royal officers who dispatched the spices of India to Portugal in royal ships. The kings of Portugal were not different from the ancient kings of Egypt in keeping control of the all-important and highly profitable spice trade.

After his work was done and his ships loaded with a variety of spices, including large quantities of pepper, Cabral sailed for home and arrived at Lisbon late in the year 1501. Whether because of his intentional or accidental deviation to Brazil, or because he returned to Portugal with only six ships of the thirteen that had set out from Lisbon, King Emmanuel's reception was very cool, and Cabral retired to private life.

The aromatic trail had led Cabral, intentionally or otherwise, to Brazil adding another diamond in the crown of Portugal. And on this same Indian voyage, one of Cabral's ships discovered the island of Madagascar. Amerigo Vespucci was sent to the newly discovered land of Brazil to claim all that he might for Portugal, and from this explorer, America took its name.

The territorial and commercial expansion of Portugal under the impetus of the spice trade made phenomenal progress in the 16th century. Portuguese navigators discovered Ascension Island in 1501, and the island of St. Helena in 1502. In 1502, Vasco da Gama made a second voyage to India with twenty ships and began the conquest and subjugation of the Moslems. He strengthened the factories which Cabral had established in the ports of the Malabar coast, loaded his ships with spices, and returned to Portugal. Vasco da Gama was later appointed Viceroy of India and took up residence at Goa, but this great and honored navigator lived only a few months after his arrival in India and died at Cochin December 24, 1524. On March 25, 1505, the Portuguese nobleman Dom Francisco de Almeida sailed for India with sixteen large ships and sixteen caravels carrying 1,500 soldiers and numerous officials in the king's service. On the outward voyage, they successfully attacked Quiloa and Mombasa and erected forts at these places to provide convenient resting stations on the West African coast for Portuguese ships engaged in the Indian spice trade. Almeida arrived at Cannanore October 22nd and assumed the title of Viceroy of Cochin, Cannanore and Quilon. Attracted by the cinnamon of Ceylon, he visited that island in 1506. He was superseded by Albuquerque in 1509.

Alfonso de Albuquerque was born in 1453 at Alexandria, near Lisbon. He was educated at the court of Alphonso V, and his later exploits and accomplishments in the service of Portugal earned him the surname of "The Great." In 1503, he made a voyage to India by way of the Cape of Good Hope, and returned to Portugal in 1504. Of a fleet of sixteen ships which sailed from Portugal for India in 1506 under the command of Tristan da Cunha, Alfonso de Albuquerque had a subcommand of a squadron of five ships. After a number of engagements with Moslems on the east coast of Africa, Albuquerque separated from da Cunha and sailed north. He was aware of the importance of the Island of Hormuz in the Persian Gulf and the port of Aden at the entrance of the Red Sea in the great spice trade of the Orient. The possession of Hormuz would give the Portuguese absolute control over the spice trade between the Persian Gulf and the Orient, and similarly the possession of Aden would give them control of the spice traffic to the Red Sea. If Portugal held these two vitally strategic ports all traffic in spices to Basra, Bagdad, Constantinople, Mecca, Cairo, Alexandria and Venice, which depended on the sea lanes, would be cut off. Such a conquest would end the Moslem supremacy over the spice trade in that part of the world and would deal a death blow to Venice. Consequently, Albuquerque attacked and captured the island of Hormuz, but, unfortunately, growing unrest among his officers and men made his position untenable and he was compelled to withdraw from the island.

From Hormuz, Albuquerque sailed to India and arrived on the Malabar coast late in the year 1508. He presented to Dom Francisco de Almeida a commission from the king which instructed that nobleman to turn over the viceroyalty to Albuquerque, but Almeida put him in prison instead. On the arrival of the Grand Marshal of Portugal at the head of a large fleet, Albuquerque was released and assumed the governorship. In 1510, he attacked and captured Goa.

On September 11, 1509, the Portuguese navigator Diogo Lopes de Sequeira anchored off the city of Malacca where he had arrived on a voyage of exploration to find the famed Spice Islands. Treachery on the part of the native chief compelled Sequeira to abandon his plans and return to India, but he had seen and heard enough about the great abundance of spices in those parts to interest Albuquerque in Malacca and the island of Sumatra. Albuquerque sailed for Malacca and in 1511, that ancient spice emporium fell to the Portuguese. He strongly fortified the city which remained under Portuguese control until 1641 when it fell to the Dutch. Albuquerque was now rapidly closing the sea lanes to the hated Moslems. He had written: "...if we take this trade of Malacca away out of their hands, Cairo and Mecca will be entirely ruined, and to Venice, no spices will be conveyed, except what her merchants go and buy in Portugal."

The Portuguese were now in control of the spice trade of the Malabar coast of India, Ceylon, and of Sumatra and Java. To explore the Spice Islands was the next objective of Albuquerque. In the closing days of 1511, he sent an expedition of three ships under the command of Antonio D'Abreu from Malacca to find the islands from where came the nutmegs, mace, and cloves; one of these ships was captained by Francisco Serrano, a close friend of Ferdinand Magellan. After some exploration of Java and other islands, and the loss of one ship, D'Abreu and Serrano arrived at the Banda Islands where they obtained cargoes of cloves and nutmegs. But only one ship arrived back at Malacca. Meeting with a violent storm, Serrano was shipwrecked near Amboyna. He managed to make his way from Amboyna to Ternate where he settled permanently. In 1514, a second expedition sailed from Malacca for the Spice Islands and successfully reached Ternate. This island remained the principal trading centre of the Portuguese in the Spice Islands during their ascendancy over the spice trade of the East Indies.

Albuquerque next turned his attention to the unfinished task of bottling up the Persian Gulf and Red Sea. He had whipped the Moslems in the eastern seas and deprived them of the great oriental spice trade. It was now his ambition to wipe them out in the Middle East. He sought to recapture Hormuz, to proceed against Massawa and Aden, to capture Dalaka, to "exterminate the Rumes," and to destroy Mecca. In 1515, he retook Hormuz and heavily fortified the island. This strategic port remained

Portuguese until captured by the English in 1622. He did not succeed in capturing Aden or dominating the Red Sea, but his conquest of Malacca and the Portuguese control of the Malabar ports of India practically ruined the spice trade for the Moslems of the Middle East.

Alfonso de Albuquerque died at sea December 16, 1515. His body is buried at Goa, India. In six years of viceregal responsibility, this great man had destroyed the power of Moslems and opened the seas to the ships of Emanuel from the Cape of Good Hope to the Spice Islands. He had followed the aromatic trail to its end and enriched his country with the wealth of the great oriental spice trade. He had brought honor to his king, great prestige to his native land, and lasting fame to his name.

The Portuguese lost no time in consolidating their position in the East Indies. They were securely entrenched at Malacca and effectively commanded the strait and they built forts at Amboyna, Halmahera, Celebes, Ternate, and Tidore, where they had spice trading factories. They were not very successful in protecting their interests in the Banda Islands and because of the persistent, and at times violent, opposition of the natives, they were not able to fortify adequately the large islands of Sumatra and Java. On the island of Sumatra, the Moslem natives doggedly fought the Portuguese for the control of the pepper trade of the island, particularly in the north. On the island of Java, similar conditions obtained. The hatred which existed between the Christian invaders and the Moslem defenders cannot be overemphasized and almost everywhere they went, the Portuguese met with cunning, subterfuge and frustration, if not violence. But the Portuguese were not deterred and went steadily ahead with their program of exploitation of the East Indies. Native junks were found in the south China Sea, along the coast of Borneo and the Banda Sea and, in the interest of monopoly, the Portuguese resorted to all sorts of methods to curtail these island traders. They did not intend that any spices should leave the East Indies except in Portuguese ships.

From Malacca, the Portuguese reached out to Burma, Siam, China and Japan. Long pepper grew in the forests of Burmese Tanasserim, black pepper in Siam, but these countries did not export their meagre spices at that time, and the Portuguese saw them more as potential markets. Back in Albuquerque's day in Malacca, envoys had been sent to the Asiatic mainland. In 1511, an envoy was sent to investigate trade possibilities at Tanasserim, Martaban and Pegu in Burma. In the same year, Duarte Fernandez was sent to Siam, the first European to visit that country. In 1514, the Portuguese established themselves on an island off the coast of the Chinese province of Kwantung and in ports of the province of Fukien. In 1516, a treaty was concluded between Siam and Portugal and a trading post was established at Pattani. In 1519, Anthony Correa succeeded in making a trade agreement for Portugal with the Lord of Martaban. Fernao Pires de Andrade reached Peking, China, in 1520, but unfortunately for that Portuguese envoy, he was treated as a spy and died in a Cantonese prison. The Portuguese succeeded in establishing a settlement near Ningpo which was wiped out by massacre in 1545; another Portuguese settlement in Fukien province met a similar fate in 1549, but they finally succeeded in establishing a permanent base at Macao. Japan was accidentally discovered by three Portuguese traders in 1542. Such was the ambitious program of the Portuguese who sought to unlock the doors of Asia with the golden key of the Spice Islands.

The Moslems and Venetians throttled, the Portuguese now held a stranglehold on the spice trade in Europe. The price of pepper and other spices began to soar in all parts of Europe and resentment grew as strong against the Portuguese as it had grown against the Middle East monopolists before them. Other European powers sought a means of breaking the grip of Portugal on the spice trade of the Orient, and intrepid mariners presented themselves at the courts of Europe with plans which would carry them to the Spice Islands and open a way for these powers to share in the great spice wealth of the East. Magellan sailed for Spain; Drake, Fenton, Cavendish, and Lancaster, for England; and before the 16th century slipped into the past, Van Houtman for Holland.

XIII. FERDINAND MAGELLAN'S QUEST FOR THE SPICE ISLANDS

FERDINAND MAGELLAN was born of noble family in the year 1480 at Sabrosa, in the province of Traz-os-Montes, Portugal. Of his childhood practically nothing is known, but as a youth he entered the royal court of Portugal to serve as a page to Queen Eleanor, consort of John II.

Of all his studies at court, he would find that of the history of his own century the most interesting. No young man with a spark of romance and adventure in his breast could read of the life of Prince Henry the Navigator and of the deeds of his intrepid explorers without being thrilled. He would see himself a part of that golden age of discovery and dream of the day when he, too, would stand on the poop of a great ship and direct his gaze to a distant foreign strand. Through his years at court, impatiently waiting to grow into manhood, he would hear of the wonderful achievements of Columbus for Spain, Cabot for England, and Vasco da Gama for his own country. Almost daily, he would hear fascinating tales of new lands and new conquests, of the spice treasures of India, and of the wealth of the fabulous Spice Islands which lay somewhere in the China Sea. No western navigator had yet reached the famed Spice Islands and the thought that he might be the first to set foot on them would seize his imagination and set his adventurous heart racing. And he would determine to take the first opportunity to sail in the king's ships.

So we find Magellan, at twenty-four, embarked on a great adventure as a volunteer member of the expedition to India in 1504 under Dom Francisco de Almeida. During the next seven years, he experienced all the vicissitudes of a life at sea dedicated to discovery and conquest. He knew the joy of sailing through deep blue seas under clear sunlit skies; the creak of the timbers as the tall masts strained to the weight of billowing sails; the cries of the sea birds, the dance of the porpoise, and the glitter of the sun on the widespread fins of the flying fish, gliding swiftly over the water; the sparkling stars and the silvery moon of the tropical night; the welcome cry of "Land Ho!" and the excitement of seeing foreign shores and people. But he also knew the drudgery and monotony of long voyages; the squalor and discomfort of crowded quarters; the stink of putrid water and the taste of rotten food; the exhaustion of tropical heat; the lash of squalls and tempests, and the bloody bite of battle.

Magellan visited the ports of the Malabar coast of India, Sofala on the east coast of Africa, and Malacca in distant Malaya. He was wounded in battle at Cannanore, in 1506, and again at Diu, in 1509. He sailed with Diogo Lopes de Sequeira from Cochin on August 19, 1509 on a voyage intended for the exploration of the Spice Islands, but which did not get beyond Malacca. In 1510, he was promoted to the rank of Captain. Under Albuquerque, he distinguished himself at the conquest of Malacca in 1511. And in June 1512, he was back in Portugal. It had been a great apprenticeship for his momentous undertaking a few years later, and he had served his country well.

Following the conquest of Malacca, Magellan is said by some authorities to have sailed in command of one of the three ships of the expedition sent out by Albuquerque to explore the Spice Islands. Antonio D'Abreu was in command of the flagship, and Magellan's good friend Francisco Serrano was in command of the third ship. We can be sure that there was nothing closer to the heart of Magellan than to have the opportunity of exploring the Spice Islands, and certain it is that he would have jumped at the chance to be again with Serrano. But other authorities, for chronological reasons, contend that Magellan could not possibly have sailed on that expedition. They point out that the squadron did not sail from Malacca until late in December 1511 and that Magellan was home in Portugal by June 1512, and they state that it is out of the question for Magellan to have explored the Spice Islands and returned to Portugal within six months. These authorities believe that Magellan returned to India on board one of Albuquerque's ships, following the fall of Malacca (July to August 1511), and arrived on the Malabar coast in time to join a homeward bound vessel.

In 1513, Magellan took part in the fighting at Azamor in Morocco and was again wounded, this time lamed for life. Following this engagement, he was accused of illicit trading with the Moors and fell into disgrace. The accusation was subsequently withdrawn, but King Emanuel had no further use for him and he was dropped from the service of Portugal. Bitterly disappointed and peeved, Magellan later left Portugal for Spain where he offered his services to Charles V.

King Emanuel had made a mistake. Magellan was a good officer, a brave fighter, a good navigator, and a man of enterprise. By breeding and up-bringing, he was a man of distinction, informed, intelligent, and imaginative. The same characteristics which had led him to a life of adventure at sea and carried him successfully through his years of service abroad were now urging him forward to an undertaking destined to bring great honor and lasting fame to his name.

Magellan had never stopped thinking about the wondrous Spice Islands and their reported abundance of cloves, nutmegs, and other treasured aromatics of the orient, and now his mind was pounding away at the idea of reaching these islands by sailing across the Atlantic on a westerly or west by south course. Malacca lay in the equatorial region far to the east, and the Spice Islands still farther—so far that they must be somewhere just beyond the land discovered by Cabral. Why sail all the way south to the Cape of Good Hope and then thousands of miles to the east? Was the world not round? If one sails continuously to the east one must arrive in the west, and the reverse must also hold true! Had it not been demonstrated that with fair winds the run to the newly discovered western lands could be made in much less time than it took the king's ships to reach India, let alone Malacca? Then was it not logical to sail in the shorter westerly direction to reach the eastern Spice Islands? Somewhere through the western land mass, there must be a passage leading to the eastern seas, and if there is none, he will follow the coast of Brazil to the south and he may find it possible to round the country just as Bartholomew Diaz had done when he sailed south along the coast of Africa and rounded the Cape of Good Hope. Certainly there was everything to be gained by making the attempt! Columbus and Cabot had not been wrong in sailing to the west to find the rich spice lands of the East, it was only that they had not sailed far enough or had failed to find a passage through the lands they had discovered. And so would go the thoughts racing through his mind.

Magellan, in common with the geographical knowledge of his day, had no idea of the real distance across the western hemisphere between Europe and the Far East, and he doubtless imagined that once at the other side of the recently discovered western lands he would sail within a few days right into the heart of the Spice Islands.

Dismissed from the king's service, Magellan was now free to turn his attention to a full investigation of these ideas and he sought information from pilots and navigators and from one Ruy Faleiro, a scholar and famed astronomer. He thoroughly checked all the latest geographical data, went carefully over the details of past ocean voyages to the west, and minutely examined all the charts at hand. The story goes that Magellan came across a chart in the royal library on which was marked a strait cutting through the southern mainland of the New World and connecting the two oceans. If such a chart existed, it would seem that the strait which was to bear the name of Magellan had already been discovered, but again it may have been that the cartographer was one of those who believed that a passage must exist to permit the free flow of waters about the globe and so, when drawing his map, put a strait through the southern part of the western land mass. There must be something to the story because Pigafetta, a member of Magellan's staff aboard *Trinidad* clearly states in his journal, "The Captain General Magellan who knew he had to navigate through a very secret strait, which he had seen, in the treasury of the King of Portugal, marked in a chart drawn up by that most excellent man Martin de Boemia." Magellan heard occasionally from his friend Serrano, who was now settled in Ternate, receiving from him information about the Spice Islands. And he wrote Serrano, telling him that he would soon be with him because he was coming to the Spice Islands, "if not by way of Portugal, then by way of Spain."

It was no use for Magellan to waste time at the court of Emanuel, so, his plans complete, he left Portugal in the fall of the year 1517. He went to Seville and from there to Valladolid to seek an audience with Charles V. Magellan was fully aware of Spain's eagerness to reach and to possess the Spice Islands and he must have been quite confident that, with the help of some influential friends, Charles V would do for him what Ferdinand and Isabella had done for Christopher Columbus. He was not wrong. On March 22, 1518, the articles of agreement were duly signed. Magellan and Faleiro were to get five per cent of the net revenues derived from the lands discovered by them. Ruy Faleiro, the astronomer, had assisted Magellan in working out the details of his plan, but did not sail with him.

Preparations for the voyage began at once and five ships: *Santo Antonio*, 120 tons; *Trinidad*, 110 tons; *Concepcion*, 90 tons; *Victoria*, 85 tons; and *Santiago*, 75 tons, were overhauled, made seaworthy, stored, and manned. Magellan selected *Trinidad* for his flagship and on September 20, 1519, the fleet sailed from San Lucar to find the passage through the western land that would lead them into the eastern sea and to the Spice Islands. The aromatic trail was again making history!

On Magellan's staff, there was an Italian gentleman and scholar, Antonio Pigafetta, whose strong desire to see the wonders of the deep led him to volunteer his services to the Captain-General. Pigafetta kept a faithful account of all that he saw and heard. We are indebted to his journal for the information we have of this historic voyage.

A course was set for the Canary Islands, where the five ships arrived safely and anchored at Tenerife on September 26th. After taking some supplies and fresh water, the voyage was resumed; Pigafetta notes that on October 3rd "we made sail directly towards the south." Apparently they sailed close to the African coast until they were in the equatorial regions and then altered course to the southwest to bring them to the Brazilian coast. They crossed the line and sighted land at Cape St. Augustine, and then coasted south to Rio de Janeiro where they arrived December 13th.

After obtaining supplies of fresh vegetables and water, they continued slowly south, carefully examining every bay and inlet for the strait which was to lead them to the eastern sea and the Spice Islands. The River Plate was reached and entered, but an exploration by one of the vessels showed it to be a great fresh water river and the ships returned to the coast. The search was continued until late in the month of March 1520 when, finding themselves beyond the 49th latitude south and off a suitable bay, Magellan decided they should put in and shelter for the next few months from the stress of the southern winter. This was the harbor of Port San Julian.

On the voyage south the fleet had met with the usual calms in the doldrums and had battled its way through a fierce gale near the Plate. Pigafetta had noted with interest strange sea birds, flying fish, and man-eating sharks; and the commander of *Santo Antonio* had exhibited some strange conduct.

At Port San Julian, the smouldering resentment of some of the Spanish officers and men against their Portuguese Captain-General, which had shown its ugly presence on the run south, broke into flame and Magellan was compelled to deal ruthlessly with the ringleaders and sternly with their followers. His aim was the discovery of a strait and the reaching of the Spice Islands and he could tolerate no breach of discipline if the greatest undertaking of his life was going to be a success. One mutineer was stabbed to death, another beheaded, and still another marooned on shore together with a priest. Several men were sentenced to death, but later pardoned.

Following the mutiny, *Santiago* was sent out to explore the coast to the south, but unfortunately ran into very heavy weather and the ship, but not the crew, was lost.

Late in August 1520, the four ships sailed from Port San Julian and Magellan resumed his search for the strait. On October 21st, he came to a great inlet in the rugged coast—the opening of the strait which he had sought so patiently. Then followed thirty-eight days of anxious reconnaissance, exploration, and navigation of the winding passage we now call the Straits of Magellan. Here, *Santo Antonio* parted from the fleet, put about, and sailed for Spain. The remaining three ships successfully traversed the strait and emerged in the Pacific Ocean, November 28th. This much of his plan to reach the Spice Islands by the westerly route had been realized, and now for the Spice Islands themselves! At that moment, Magellan must have experienced a deep feeling of satisfaction. Very soon now, he would be able to stake the claim of Spain to the possession of the wealthy Spice Islands, greet his old friend Francisco Serrano, and load his ships to capacity with cloves and nutmegs.

They sailed into the broad expanse of the ocean before them with high hopes and followed a course to the north and then to the northeast for three months and twenty days. All this time, the weather was calm and peaceful, but the conditions aboard their little ships were dreadful. Pigafetta wrote in his diary:

> On Wednesday, 28th November, we left the strait, and entered the ocean to which we afterwards gave the denomination of Pacific, and in which we sailed the space of three months and twenty days, without taking any fresh provisions. The biscuits we were eating no longer deserved the name of bread; it was nothing but dust, and worms which had consumed the substance; and what is more, it smelled intolerably, being impregnated with the urine of mice. The water we were obliged to drink was equally putrid and offensive. We were even so far reduced, that we might not die of hunger, to eat pieces of the leather with which the main-yard was covered to prevent it from wearing the rope. These pieces of leather, constantly exposed to the water, sun, and wind, were so hard that they required being soaked four or five days in the sea to render them supple; after this we broiled them to eat. Frequently indeed we were obliged to subsist on sawdust, and even mice, a food so disgusting, were sought after with such avidity that they sold for half a ducat a piece.
>
> Nor was this all, our greatest misfortune was being attacked by a malady in which the gums swelled so as to hide the teeth, as well in the upper as the lower jaw, whence those affected thus were incapable of chewing their food. Nineteen of our number died of this complaint....
>
> Besides those who died, we had from twenty-five to thirty sailors ill, who suffered dreadful pains in their arms, legs, and other parts of the body; but these all of them recovered.*

On March 6, 1521, the three ships and their distressed crews arrived at Guam in the Marianas. The natives crowded about the little fleet and stole everything within reach, for which reason Magellan named the islands De Los Ladrones (Islands of Thieves). Says Pigafetta: "The inhabitants of these islands are poor, but very dexterous, and above all at thieving."

Having obtained supplies of fresh food and water, the voyage was resumed and on March 16th, they arrived off the island of Zamal (Samar) and, notes Pigafetta, "Behind this island is another not inhabited...Humunu." These islands were part of the Philippines and Magellan claimed them, as he did each island of the group he visited, for Spain. They were not the Spice Islands that Magellan had come in search of, but Pigafetta tells us that the natives showed Magellan their stocks of cloves, cinnamon, pepper, mace and nutmegs, "and by signs informed us that the countries towards which we directed our course produced these in abundance." The Spice Islands were not far away —but Magellan was not destined to see them.

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* *A General Collection of the Best and Most Interesting Voyages and Travels in All Parts of the World*, 17 volumes, by John Pinkerton. (Pigafetta's Voyage and Discovery of Upper India, affected by one Antonio Pigafetta, Gentleman of Vicenza, and Knight of Rodes; volume 11, book II, page 322.)

The fleet eventually reached the Philippine island of Cebu, and here, most unfortunately, Magellan agreed to assist the island king in an attempt to subjugate the neighboring island of Matan and was killed in combat April 27, 1521. Wrote Pigafetta: "There perished our guide, our light, and our support; but the glory of Magellan will survive him." The Spice Islands he so much wanted to see, he did not see; his friend Serrano he did not meet; the wealth of spices which he had looked forward to carrying from the golden Spice Islands to Spain, he did not carry; the triumph of a great reception in Spain in public acclamation of his magnificent accomplishment, he did not know. But he had discovered the strait which now bears his name; he had brought the Philippines to the Spanish crown; and he has been honored for centuries, and will be honored through the ages to come, with the fame of the first circumnavigation of the world. He had not found a short route to the Spice Islands, but he had sailed into the east by way of the west.

The three ships left the island of Cebu and sailed to the island of Bohol, where, because of diminished crews, the stores and all useful equipment were removed from *Concepcion*, and the vessel destroyed by fire. From Bohol they touched at the island of Mindanao, and then headed for Borneo where they found a "very commodious port for careening our ships." They remained in this sheltered harbor for forty-two days, and then sailed for the Spice Islands. The peak of Tidore was sighted on Novemmber 6th, and "on Friday, 8th of November, three hours before sunset we entered the port of an island called Tidore." The famed Spice Islands had been reached at last; this was the end of the aromatic trail.

Pigafetta notes that the islands which produce cloves are five in number: "Terenate, Tadore, Mutir, Machian, and Bachian." Then he gives us a colorful description of the bartering which followed their favorable reception:

> On Tuesday, 12th November, the king caused a shed to be raised for receiving our merchandise, which was completed in a single day....The value fixed on the merchandise we meant to exchange for cloves was thus fixed: for ten yards of red cloth of a fine quality, a bahar of cloves was to be received. The bahar is four quintals and six pounds, each quintal being one hundred pounds. We likewise were to have in barter the same quantity of cloves for fifteen yards of inferior cloth, for fifteen axes, or thirty-five glass goblets. After this ration we disposed of all our glass to the king. Moreover a bahar of cloves was the price given for seventeen cathils of cinnabar, for a similar weight of quicksilver, for twenty-six yards of linen, or twenty-

> five of a finer quality, for a hundred and fifty pair of scissors, or as many knives, for ten yards of Guzzerat cloth, for three gongs, or a hundred weight of copper. We should have made great profit of our looking-glasses, but most of them broke by the way, and the residue were almost wholly appropriated to himself by the king. Part of the merchandise I have mentioned was taken out of the junks we captured. We thus carried on a highly advantageous traffic, but we should have made it still more lucrative but for our eagerness to return to Spain.*

A Portuguese, by name Peter Alphonso de Lorosa, told Pigafetta of the great trade of the Portugusese between Malacca and the Banda and Molucca islands:

> ...likewise told us that a number of junks go every year from Malacca to Banda, to buy mace and nutmegs, and thence come to the Molucca islands to load with cloves.

The voyage from the Molucca islands to the Banda islands occupied three days, and that from the Banda islands to Malacca, fourteen days. Observed Pigafetta:

> This commerce is the most profitable to the King of Portugal of any carried on with these islands, and in consequence the greatest care is used in keeping secret from the Spaniards.

Pigafetta went on shore to study the clove tree. The tree that Marco Polo had described as "small," Pigafetta found "a pretty considerable height, and its trunk is about as large as a man's body, varying more or less according to its age." Pigafetta proceeds with his description of the clove tree:

> Its branches extend very wide about the middle of the trunk, but at the summit terminate in a pyramid. Its leaf resembles that of Laurel, and the bark of it is of an olive color. The cloves grow at the end of small branches, in clusters of from ten to twenty; and the tree, according to the season, sends forth more on one side than the other. The cloves at first are white; as they ripen they become reddish, and blacken as they dry. There are annually two crops gathered, the one at Christmas, the other about St. John the Baptist's day....When the year is hot, and the quantity of rain that falls is little, the amount of the crop of each island is from three to four hundred bahars...
>
> Each inhabitant possesses some clove-trees, which he gathers, but he uses no species of culture. In different islands cloves bear different names: they are called bongalavan at Sarangani, at Tadore ghomodes, and in the residue of the Malucho islands, chianche.**

Of nutmegs and ginger he has the following to say:

> This island likewise produces nutmeg-trees, which resembles our walnuts as well in the appearance of the fruit as in the leaves. The nutmeg when gathered is like a quince in shape, color, and the down with which it is covered, but it is smaller. The outward bulk is of the same thickness as the green one of the walnut; beneath, a

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* *Pinkerton's Voyage and Travels*, volume 11, book III, page 362.

** *Ibid.*, page 365.

> thin membrane or tissue envelopes the ligneous shell containing the nutmeg.
>
> Ginger also grows on this island; in a green state it is easten in the same manner as bread. Ginger is not, properly speaking, the produce of a tree, but of a sort of shrub, which shoots up suckers about a span in length, similar to the shoots of canes, the leaves, too, like those of the cane, except in their being more narrow. These shoots are of no value, the root only being the ginger used in commerce. Green ginger is not so strong by much as when dried; and to dry it lime is used, for otherwise it could not be preserved.*

Perhaps we should give you here his description of cinnamon which he had noted growing on the island of Borneo:

> Having seen the cinnamon tree I am enabled to give a description of it. It is from five to six feet high, and no thicker than one's finger. Never has it more than three or four branches: the leaf is similar to that of the Laurel: the cinnamon we use is merely the bark of the tree, which is stripped off twice in the year. The wood itself even, and the green leaves have the same aromatic flavor as the bark. It is called cainmana from cain, which signifies wood, and mana, sweet.**

To Pigafetta and the crews of the two Spanish ships, the small island of Tidore must have seemed a veritable paradise; truly one of the golden isles laden with pungent cloves and other treasured spices. In Europe, these spices were worth their weight in gold and here they could be bought for a song; every man avidly sought his share:

> On Thursday and Friday [December 4th and 5th] we purchased a large quantity of cloves, which were afforded us at a low rate on account of our being near the time of our departure. We received a bahar for a few yards of ribband, and a hundred pounds weight for a few small chains of brass, which only cost a marcel and as every sailor was anxious to carry to Spain as much as he could, every one bartered his property for cloves.†

The Spaniards had a wonderful time; they had been made welcome during their stay in the Spice Islands and they had loaded their two ships until they groaned beneath the weight of pungent spices. They were now ready for sea, anxious to start the long voyage home. On December 11, 1521, farewells were said, and the two ships weighed anchors. The first to get underway was *Victoria*, but she had not gone far before she saw that something was wrong with *Trinidad* and returned to her anchorage. After weighing anchor, *Trinidad* was found to be leaking. Her pumps were kept going for two days, but to no avail; the water was coming through the seams too fast. The king of Tidore ordered his divers to examine the ship's bottom. Five of them dived beneath the water and staying close to the hull let loose their long hair so that the water might carry it to the places in the hull where the leaks existed; they worked for more than half an hour, but without success. After everything had been tried and the condition found to be hopeless the decision was made to beach *Trinidad* so that her crew could discharge whatever quantity of the cargo it would be found necessary to put on shore, and proceed with repairs.

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* *Pinkerton's Voyage and Travels*, volume 11, book III, page 365.

** *Ibid.*, page 357.

† *Ibid.*, page 368.

Fearing a like experience, *Victoria* lightened her own cargo by discharging sixty hundredweights of cloves, and again made ready for sea. On Saturday morning, December 21st, the king of Tidore sent two pilots to *Victoria* to guide her clear of the shoals. At noon she weighed anchor, and "the two vessels then bade adieu to each other by a reciprocal discharge of artillery. Our comrades followed us as far as they were able in their boat, and we parted in tears. Juan Carvajo [commander of *Trinidad*] remained at Tadore with fifty-three Europeans and thirteen Indians." Sebastian del Cano was in command of *Victoria*, and Pigafetta was with him. They sailed south, and finally left the East Indies by way of the island of Timor, February 11, 1522. Del Cano laid a course for the Cape of Good Hope and en route to this cape, his crew suffered terribly from lack of food. Pigafetta tells us that their meat went putrid because they had no salt and were unable to save it by pickling and they were compelled to subsist on rice and water. Many of the men were sick. Off the Cape, the weather was very bad:

> We were obliged to remain nine weeks opposite the Cape with our sails lowered, on account of the west and northwest winds which constantly blew, and which terminated in a dreadful tempest.

On May 6th, they "doubled the terrible Cape," and sailed northwest throughout May and June, during which time they lost twenty-one men including Indians. Pigafetta notes:

> We made a singular observation on throwing them into the sea; the corpses of the Christians floated with the face towards heaven, but those of the Indians with the face downwards.

Their plight was desperate:

> We were now wholly destitute of provisions, and had not heaven favored us with fine weather, we should have all perished with hunger. On the 9th of July, on a Wednesday we distinguished Cape Verde Islands, and anchored off that called Saint Jago.

Sebastian del Cano took a terrible risk calling at this Portuguese possession, but he was desperately in need of food and water for his men. He managed to get supplies and to get clear of the island, but only with the loss of thirteen men who had been taken prisoners by the Portuguese when it was discovered that *Victoria* was a Spanish ship.

Pigafetta was greatly surprised to learn that the day was not really Wednesday but Thursday when *Victoria* arrived at this island on July 9, 1522; he had faithfully noted in his diary the events of each and every day and could not understand how the day of arrival could be other than a Wednesday. He learned later that by sailing westerly into the east a day had been gained.

On Saturday, September 6th, the little ship entered the bay of San Lucar and on Monday, September 8, 1522, she anchored off the mole of Seville, "and fired the whole of our artillery." Of sixty men, who had composed the crew of this gallant ship when she left the Moluccas, only eighteen remained, "most of whom were sick."

Magellan did not see that great day; death held him in far-off Matan. But life warmly breathed his name. His great undertaking was completed; he had found the western route to the eastern Spice Islands; and through *Victoria*, he had successfully circumnavigated the world. The glory was his. The winding, rugged, stormy, 350-mile long Straits of Magellan remains his indestructible monument.

The cloves were sold at a most handsome profit, and Charles V of Spain was well pleased. He honored Sebastian del Cano with a coat of arms which included in its arrangement two cinnamon sticks, three nutmegs, and twelve cloves. He also gave him a very good pension.

The golden trail of the spices was more brilliant than ever!

XIV. THE BRITISH SEEK NORTHEAST AND NORTHWEST ROUTES TO THE SPICE ISLANDS

THE arrival of *Trinidad* and *Victoria* in the Spice Islands was a most unwelcome sight to the Portuguese. These were Spanish ships which had found their way to the Spice Islands by a westerly route from Europe, they had been most favorably received, and were loading full cargoes of cloves. Undoubtedly, others would follow in the wake of these two unless something was done promptly to prevent this Spanish invasion of the Spice Islands, which, under the terms of the Treaty of Tordesillas, the Portuguese considered to be theirs by discovery and conquest. To the Portuguese, the coming of these ships was nothing less than a flagrant violation of treaty rights, and the matter was brought at once to the attention of the home government.

The 1494 Treaty of Tordesillas modified two bulls of Pope Alexander VI issued in 1493 and established a line of demarcation running longitudinally 370 leagues west of Cape Verde Islands. All lands discovered west of this line were to belong to Spain, those east, to Portugal. This division of the world took care of the discoveries of the two powers up to that time, and doubtless seemed fair and practical enough to take care of their future plans—when Cabral discovered the coast of Brazil in 1500, this land fell almost uncannily into the Portuguese zone! But when Magellan's ships reached the Spice Islands in 1521, it raised a moot point. When continued on the other side of the globe, the line of demarcation would, on our maps, put the Spice Islands safely within the Portuguese zone, but on the inaccurate maps of that time, the position of the Spice Islands and the line of demarcation were found to be anything but distinct from each other and it was very difficult to determine in whose zone they lay. This gave rise to argument between the two powers. In 1524, the dispute was submitted to a commission of enquiry, but the Spanish and Portuguese representatives could not reach an agreement and the matter dragged on. Eventually the question was settled by the monarchs themselves. In 1524, John III of Portugal, who succeeded to the throne on the death of Emanuel in December 1521, married Catherine, sister to Charles V of Spain, and shortly afterwards Charles V married the Infanta Isabella, John's sister. This close family association had probably much to do with the reaching of an agreement between the kings and in 1529, Charles ceded to John any rights he may have had to the Spice Islands for the sum of 350,000 gold ducats.

In the meantime, however, Charles V of Spain was going right ahead with his plans to get his share of the treasured spices of the Moluccas and on March 4, 1525, Sebastian Cabot was appointed to the command of an expedition which was to sail to the Moluccas and the lands of Tarsis, Ophir, Cipangu and Cathay, Sebastian, when a young man, had sailed with his father, John Cabot, on his memorable voyage from Bristol across the western ocean in search of Cipangu "where he thinks all the spices of the world . . . originate," and was doubtless considered experienced and well informed in matters of discovery. In command of a small fleet of three ships, Sebastian Cabot sailed from Spain in April 1525, evidently intending to follow the route of Magellan. By June he was off Brazil and proceeding south along the coast. Near the River Plate, he found three Spaniards who had been with Juan Dias de Solis on his 1516 expedition to those parts and who told Cabot of a wealth of silver to be found in the country bordering on that great river. Lured by this report, Cabot abandoned his voyage to the Moluccas and other places, and arriving at the Plate in February, 1527, he explored the river for some miles and founded Fort Sancti Spiritus.

Cabot had doubtless concluded that the reported wealth of the Argentine country would justify his action, but Spain wanted spices and new lands. On his return to Seville in August 1530, he was banished to North Africa for a period of four years. Had Cabot kept to the aromatic trail, he might have added to the historic accomplishments of Spain; but this was not his destiny.

Cabot was permitted to return to Spain in 1533 and was reinstated in his former position of pilot major. In 1548, he went to England where he was named Grand Pilot of England and received a pension from Edward VI. He became the first governor of the Company of Merchant Adventurers.

As far back as the year 1527, when one Robert Thorne, a British merchant then resident in Seville, Spain, had written Henry VIII and called his attention to the possibility of a passage to the spice lands by way of the north, merchants in England had been interested in a route to the east by this direction and Cabot organized their first expedition. Thorne had said:

> I know it is my bounden duety to manifest this secret unto your Grace, which hitherto,

> as I suppose, hath beene hid: which is, that with a small number of ships there may bee discovered divers New lands and kingdomes, in the which without doubt your Grace shall win perpetuall glory, and your subjects infinite profite. To which places there is left one way to discover, which is into the North: . . . it is very cleere and certaine, that the Seas that commonly men say, whithout great danger, difficulty and perill, yea rather it is impossible to passe, that those same Seas be navigable and without anie such danger, but that shippes may passe and have in them perpetuall clerenesse of the day without any darkenesse of the night: which thing is a great commoditie for the navigants, . . . For they being past this little way which they named so dangerous, (which may be two or three leagues before they came to the Pole, and as much more after they passe the Pole) it is cleere, that from thence foorth the seas and landes are as temperate as in these parts. . . If they will goe toward the Orient, they shall injoy the regions of all Tartarians that extend toward the midday, and from thence they may goe and proceede to the land of the Chinas, and from thence to the land of Cathaio Orientall, . . . and from thence . . . fall in with Malacca, and so with all the Indies which we call Orientall, and following the way, may return hither by the Cape of Buona Speransa: and thus they shall compasse the whole world. . . . By this it appeareth, your Grace hath not onely a great advantage of the riches, but also your subjects shall not travell halfe of the way that other doe, which goe round about . . .*

Thorne enlarged on his convictions in a communication to "Doctour Ley, Lord ambassadour for king Henry the eight." In part he says:

> Now then if from the sayd New found lands [by John Cabot] the sea be navigable, there is no doubt, but sayling Northward and passing the Pole, descending to the Equinoctial line, we shall hit these islands [Spice Islands], and it should be a much shorter way, then either the Spaniards or the Portingals have. . . . The navigation of the Portingals to the said Islandes is departing from Portingall Southward towarde the Cape Verde, and from thence to another Cape passing the line Equinoctial called Capo de bona speransa, and from Portingal to the Cape is 1800 leagues, and from this Cape to the Islands of Spicerie of the Emperour is 2500 leagues.
> So that the navigation amounteth all to 4300 leagues. So that (as afore is sayd,) if between our New found lands or Norway, or Island, the seas toward the North be navigable, we should goe to these Islands a shorter way by more then 2000 leagues.**

All this would be known to Sebastian Cabot and his colleagues and it doubtless sounded very convincing. If they were going to discover a new and shorter way to the Spice Islands, this must be it! And so, the "Ordinances, instructions, and advertisements of and for the direction of the intended voyage for Cathay," were "compiled, made, and delivered by the right worshipfull M. Sebastian Cabota Esquier, governour of the mysterie and companie of the Marchants adventurers for the discoverie of Regions, Dominions, Islands, and places unknowen, the 9. day of May, in the yere of our Lord God 1553," and three ships sailed from England in the same month and year to seek the short route to the Spice Islands by way of the lands of the Midnight Sun.

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* *Hakluyt's Voyages*, volume 1, pages 214–216.

** *Ibid.*, pages 227, 228.

Built of stout oak planks which had been sheathed with lead to keep out the destructive teredo, stored for eighteen months, and manned with a complement of 118 officers and men, the three ships, *Bona Esperanza,* 120 tons, Sir Hugh Willoughby, Captain General of the fleet; *Edward Bonaventure,* 160 tons, Richard Chancelor, Captain and Pilot Major; and *Bona Confidentia,* 90 tons, Cornelius Durfoorth, Master, sailed from Ratcliffe on the Thames, said farewell to the court and privy councillors as they passed Greenwich, waited for wind and tide at Woolwich, and departed on their voyage from the east coast port of Harwich.

The fleet safely made the Norwegian coast, and on the voyage northward Sir Hugh Willoughby, deciding that certain plans should be made for the guidance of the ships in the event of their dispersal in heavy weather, communicated with his commanders and fixed Vardohus in Norway as a rendezvous. At 4 P.M. on the very day this arrangement was made, the fleet ran into a terrific gale during which the ships were driven off their course and widely separated. *Edward Bonaventure* rode out the storm, and made for the prearranged meeting place. There Chancellor waited for seven days, but the other two ships did not turn up. It seems they survived the storm only to be caught in the ice of Lapland where both crews perished from the intense cold.

The violence of the storm and the disappearance of the two ships had unnerved Chancellor's men and they were not without misgivings about the future of this voyage into the unknown, but they agreed to stand by their commander and the voyage was continued. They sailed steadily to the northeast and eventually came "to the place where he found no night at all, but a continual light and brightness of the sun shining clearly upon the huge and mighty sea," and then to a "certain great bay." They had arrived off the mouth of the Dvina in the White Sea. From native fishermen, who were at first terror stricken at the sight of the strangers and their great ship, Chancellor learned that he was in Russia.

He soon gained the confidence of the native people and in due course made arrangements with their governor to make an overland trip to Moscow. After a long, miserably cold journey of fifteen hundred miles by sled and other means of transportation, Chancellor finally reached the capital and came into the presence of Ivan, first Tsar of Russia, and later known as "The Terrible." Chancellor was most favorably received and entertained by the Tsar, and came away from the court in possession of valuable trade concessions.

He returned to the White Sea and rejoined his ship. The voyage home was uneventful save for some minor trouble with pirates, and late in the summer of 1554, the good ship *Edward Bonaventure* with Chancellor and his gallant crew docked in London.

Richard Chancellor had not reached Cathay, he had not found spices, but in his attempt to do so he had found a new market for the merchants of England. As a result of his voyage the Company of Merchant Adventurers obtained a royal charter in 1555 and became known as the Muscovy Company; Sebastian Cabot was appointed Governor and trade with Russia began.

Chancellor returned to Russia in 1555 and stayed there until late in July of the following year, when he sailed for England aboard his ship *Edward Bonaventure*. On the voyage home, he encountered very heavy weather and he made for the Scottish coast and anchored off Pitsligo, Aberdeenshire, November 10, 1556. The anchor had not lain on the bottom many hours when a sudden storm struck the vessel and broke her cable. Helplessly adrift, it was not long before she was driven on the rocks of the rugged shore and wrecked. Many of the crew saved their lives, but not Richard Chancellor; he was drowned when a little boat, in which he was trying to make the beach, was swamped.

Further attempts were made to find a route to the Far East by the northeast passage, but to no avail. Stephen Burrough in 1556 came near Novaya Zemlya, but was unable to proceed farther because of the strong northeasterly winds and the ice masses. Anthony Jenkinson made his first trip to Russia in 1557 by way of the White Sea and tried to reach Cathay by an overland route, but got no farther east than Bokhara. He was equally unsuccessful in later attempts.

It was apparent by now that the English were not going to find the "balmes, spices, and other things," of the Orient by sailing round the North Cape and so they turned their attention to the possibilities of finding a northwest passage. Sir Martin Frobisher sailed June 7, 1576, with two small ships, *Gabriel* and *Michael*, and headed into the North Atlantic by way of the Shetland Islands. He lost a pinnace in bad weather and *Michael* deserted the expedition. He reached the coast of Labrador and then the bay which bears his name. Believing it to be a passage which might lead him to Cathay and India, he reconnoitered the bay for some time and then gave up for the time being. He returned to London in October of the same year. He made two more attempts, but was no more successful in finding a passage to the East than he had been on his first voyage.

These great explorers who had sailed to the northeast and to the northwest had found no passage to the rich spice lands of the Orient, but in their brave attempts, they had brought about trade with Russia and carried the flag of England to new lands in North America. They did not enable the merchants of London to share in the great wealth of the eastern spice trade, but their deeds and heroism had inspired their fellow countrymen, and many adventurous mariners stood ready to sail for Queen Elizabeth.

While all this had been going on, the Portuguese were waxing fat from their prosperous spice trade in the East Indies. They had obtained a share in the trade of the Javanese city of Bantam, from where three and a half million pounds of pepper were shipped yearly to China and India, and they had successfully concluded treaties with the Sultan of Brunei which not only opened up the pepper trade of Borneo,but enabled them to follow a better route from Malacca to the Moluccas and trade with the island of Celebes. Malacca had become a great spice-trading centre, to where all ships, large and small, that sailed the East Indian waters were bound to go and pay customs to the Portuguese. From this port, the Portuguese monopolized the clove trade of the Moluccas and the nutmeg and mace trade of the Banda Islands. But they had never known real peace with the natives. In the great pepper land of Northern Sumatra, the Achinese king stoutly opposed them and successfully carried on trade in pepper and other spices with Moslem merchants from Mecca. Moslem traders in Java steadily sniped at their trade with the Spice Islands, and shipped cloves, nutmegs, and mace to the Red Sea. Portuguese rapacity brought about an uprising in the Moluccas and in 1574 their fortress at Ternate fell to the Moslems. Then, in 1579, Francis Drake came, not by a northeast or northwest passage, but in the track of Magellan. It was the beginning of the end of the Portuguese monopoly of the spice trade of the East.

XV. SIR FRANCIS DRAKE'S VOYAGE TO THE SPICE ISLANDS

SIR FRANCIS DRAKE was born in the year 1545 near Tavistock in Devonshire, England. He was educated at the expense and under the care of Sir John Hawkins. This was the slave trading John Hawkins who sailed from Plymouth October 2, 1567, in command of a vessel named *Jesus* and who received a wound from a poisoned arrow while rounding up negroes at Cape Verde. Hawkins recovered because he accepted the timely advice of a native to apply a clove of garlic "which sucked out the poison and left him cured."

Young Drake was aprenticed to the sea and, at twenty-one, captained the *Judith*. In 1570, Queen Elizabeth granted him a regular privateering commission and he spent some time in the Caribbean Sea to the dismay of the Spaniards. He was later appointed admiral of a fleet of five ships, which sailed from Plymouth December 13, 1577 on a voyage that was to carry him round the world. His ship was the *Pelican*, but he later changed her name to *Golden Hind*.

The fleet reached the coast of Brazil in April 1578 and coasted south to Port San Julian, where they arrived June 20th after various mishaps, including the loss of two vessels. Here history repeated itself and one Thomas Doughty, whose mutinous conduct had been a matter of grave concern to Drake, was tried, found guilty of treason, and beheaded on July 2, 1578. Drake, like Magellan before him, was not going to risk the success of his expedition because of the discontent of any individual.

Drake sailed from Port San Julian on August 17th and four days later, the three ships entered the Straits of Magellan. During their passage through the straits, they observed the land on both sides to be huge and mountainous. The mountains were snow capped and the air was extremely cold. But they noted good harbors and a plentiful vegetation, including many "good and sweet herbs."

September 6th brought them into the Pacific Ocean and on the 7th, a violent storm began which drove them far to the south. The ship *Marigold* foundered and *Elizabeth* disappeared. Not until late in October, or perhaps early November, was *Golden Hind* able to proceed north along the west coast of South America. Drake called at the island of Mocha, and at the ports of Valparaiso, Coquimbo, Tarapaza, Arica, and Lima and, among other accomplishments, generally played havoc with Spanish shipping, particularly at Lima. At this port, he heard of a Spanish treasure ship called *Cacafuego* which was sailing northward and straightway put to sea in pursuit. She was overtaken on March 1, 1579, rifled of her cargo of bullion, precious stones, and jewels, and then cast off.

Two more ships were captured and plundered and then Drake resolved "to go forward to the islands of the Moluccas." He pondered the best way to reach the Spice Islands, "and finding himself where he now was becalmed, he saw that of necessity he must be forced to sail a Spanish course, namely, to sail somewhat northerly to get a wind. We therefore set sail, and sailed six hundred leagues at the least for a good wind." He sailed more than this and perhaps reached the 48th parallel of latitude, but when the crew complained about the increasing cold, Drake turned around and headed south for the land. *Golden Hind* came to an anchorage in a "fair and good bay" somewhere on the California coast north of San Francisco. Here, after being crowned by the natives, Drake took possession of the country in the name of Queen Elizabeth and called it New Albion.

Leaving New Albion on July 26th, Drake headed into the Pacific and sailed west-south-west without seeing land until Octover 13th when, in the morning of that day, he arrived at "certain islands eight degrees to the northward of the line." These islands are thought to have been the Pelews.

After taking supplies of fresh food and water, Drake sailed southwards to the Spice Islands and arrived at the island of Ternate on the morning of November 15, 1579. Apparently Drake had intended making the island of Tidore, but while coasting along a neighboring island belonging to the Sultan of Ternate, a canoe came off bringing the Sultan's deputy who persuaded him to put in at Ternate. The Moslem Sultan of Ternate had no use for the Portuguese and warmly welcomed the Englishman with whom he made a friendly alliance.

Golden Hind, already burdened with treasure, had little room to spare but she took all the cloves and other spices the remaining cargo space permitted. His business completed, Drake sailed from Ternate. Coming to a suitable cove somewhere south of the island of Celebes, a twenty-six days' stop was made to clean the weeds and barnacles off the hull and generally attend to other matters affecting the seaworthiness of the ship. Everything being shipshape, Drake sailed for home. Adverse winds compelled him to make to the northward of the Celebes and then to the southward, and in trying to clear the numerous shoals of those dangerous waters, *Golden Hind* ran hard on a rock at 8 P.M., January 9, 1580.

Drake and his men worked and sweated for twenty hours doing everything possible to save the ship from what seemed like certain disaster. Eight cannon, some stores, and three tons of precious cloves had been thrown overboard when at 4 o'clock in the afternoon of January 10th, the wind suddenly shifted from starboard to port. The crew immediately hoisted the sails, and the canvas taking the wind, *Golden Hind* heeled over as if she would capsize and then slipped clear of the rock, to the relief and great joy of all hands. After encountering many other dangers from shoals and contrary winds, *Golden Hind* finally cleared the East Indies by way of the island of Java and Drake set his course for the Cape of Good Hope.

Golden Hind rounded the Cape June 18th, and reached Sierra Leone July 22nd. After a two days' stay to provision the ship, Drake sailed for England and arrived in Plymouth harbor September, 26, 1580.

Following the aromatic trail, Drake and his men, in a little under three years, had been the first Englishmen to navigate the Straits of Magellan; probably discovered Cape Horn; sailed the Pacific Ocean perhaps as far north as latitude forty-eight; claimed North American land for the crown of England; reached the Spice Islands, seen their abundance of cloves and nutmeg, and concluded a favorable alliance with the Sultan of Ternate; sailed the first English ship round the Cape of Good Hope; brought spices to England; and circumnavigated the world. Drake enriched his queen, his country, and himself, and laid the foundation of the British Empire. Elizabeth honored him with a knighthood as a symbol of the gratitude of herself and England.

Sir Francis Drake lived through many other colorful exploits following this great achievement. Following his attack on Cadiz and Cape St. Vincent in the year 1587, he captured the Spanish vessel *San Felippe* homeward bound from the Moluccas and richly laden with many hundreds of tons of spices. He died on board his ship in the West Indies, January 28, 1596.

The exploits of this great British sailor warmed the hearts of his countrymen and many heroes of the sea followed in his path to build with might and main the sea power of England and extend the bounds of her maritime trade.

In 1582, Edward Fenton made an abortive attempt to reach China by way of the Straits of Magellan.

Sir Thomas Cavendish sailed from Plymouth, July 21, 1586, to seek the wealth of the Spice Islands and effected the third circumnavigation of the world. He navigated the Straits of Magellan, crossed the Pacific to the Ladrones, reached the Philippines, sailed south to the Moluccas, navigated the Straits of Macassar and of Bali, touched at Java, and then voyaged to England by way of the Cape of Good Hope.

Sir James Lancaster made his first voyage in search of spices in 1591. He was second in command of an expedition which sailed for the Spice Islands by way of the Portuguese route round the Cape of Good Hope. The enterprise was a succession of mishaps, costly in ships and human life, with only Lancaster's vessel reaching Penang and Malacca. He attempted no trade with the native spice producers and the only spices his ship finally brought to England came out of the holds of Portuguese merchantmen which he had attacked in the Indian Ocean.

Sir Walter Raleigh's ships were at sea in those days and in 1592, they captured a large Portuguese East Indiaman heavily laden with treasure, cinnamon and pepper, valued at £140,000.

By this time, the English were the virtual masters of the sea. The defeat of the Spanish Armada in 1588 marked the beginning of the end of Spanish sea power and the possessions and ships of Spain were attacked whenever possible by the English. In 1580, Philip II of Spain had acquired the crown of Portugal and Portuguese shipping was equally harassed; a Portuguese merchantman from the East Indies was a good prize for any English privateer. London merchants were looking in the direction of the Spice Islands and it was not long before English ships turned their attention fully on Portuguese possessions in the East.

But it was not the English who broke the power of the Portuguese in the East Indies; they concentrated more on India. It was the Dutch. The merchants of Holland were an enterprising lot and they were every bit as keen as the London merchants to reach the Spice Islands. In fact, they were determined to get their share of the highly profitable spice trade; they were already at war with Spain and they were prepared to fight the Portuguese in the East Indies if necessary. In 1595, they supplied the ships and money to send an expedition to the East Indies under Cornelis Van Houtman and in 1596, the shadow of the Dutch fell across the Portuguese in Bantam.

XVI. THE DUTCH REACH THE SPICE ISLANDS

CORNELIS VAN HOUTMAN, in command of a fleet of four ships and a complement of 284 officers and men, sailed from Holland on April 2, 1595. The fleet reached Cape Verde Islands April 26th and after a short stay to get what fresh stores they could, the long and difficult voyage to the Far East began.

The usual sparse diet of salt meat, dried cereals, and biscuits, through weeks of sailing, brought on scurvy, as it always did on long voyages under such conditions, and many men fell victims to this dreaded disease of the sea. The heavy work of handling their cumbersome ships in calms and storms and the exhausting tropical heat sickened others. The men badly needed fresh food and rest to strengthen their bodies if the voyage was to be continued, so Van Houtman put in at the island of Madagascar. On December 13th, he put to sea, but had not proceeded far when scurvy again attacked his men and he was compelled to return to the island. This time he anchored in the quiet bay of a small island off the east coast of Madagascar, where fresh food was plentiful and conditions favorable for the treatment of his men.

On February 13, 1596, the fleet again put to sea and headed for the East Indies. On June 5th, they sighted a small island off the coast of Sumatra and two days later arrived at Sumatra. They then followed the coast to the south, passed through the Sunda Strait, and sailed along the coast of Java until they arrived in the roads of Bantam where they anchored on June 23rd.

Van Houtman's voyage from Holland to the Indies had occupied over fourteen months and cost the lives of 145 men, some of whose bodies were committed to the sea, and others buried at Madagascar.

The Moslem Sultan welcomed Van Houtman and his men; the Portuguese appeared to do so, but actually were much annoyed at the coming of the Dutchmen and soon began a sly campaign of vilification against them. On July 1st, Van Houtman concluded a commercial treaty with the Sultan and hoped to begin loading his four ships with pepper, cinnamon and other spices of the East Indies, but the underhand work of the Portuguese effectively blocked progress and the spices were not forthcoming. By October, the quarrel was out in the open and Van Houtman's difficulties were such that he decided to sail from Bantam and look elsewhere for spice cargo. Just before leaving he managed to get a quantity of nutmegs and mace through the aid of a Chinese merchant. There were many Chinese trading in the East Indies and we suppose their usual philosophically calm outlook and good business sense kept them from taking sides in the differences of the Europeans.

Van Houtman sailed the coast of Java for months, looking for spices but finding only trouble. At the island of Madura, one of their vessels began to leak badly and was beached and burned. Finally, at the island of Bali, they met with success. The native Sultan was favorably disposed toward them and they were permitted to buy all the spices they wanted. The three ships were loaded with pepper and nutmegs and on February 26, 1597, Van Houtman sailed for Holland. The little fleet arrived safely in Amsterdam, but of the 284 men who had sailed from Holland, only 89 returned.

The success of Van Houtman fired the imagination of the people at home and stimulated the merchants of Amsterdam into immediate action. The pepper and cinnamon of Sumatra, Java, and Borneo; the cloves of Ternate, Tidore, Amboyna, and other islands of the Moluccas; the nutmergs and mace of the Banda Islands—all were now within reach. Ships were speedily made ready for the long voyage, manned with sturdy sailors, officered with competent, daring navigators, and staffed with discerning officials. In the year 1598, no less than five expeditions left Holland for the East Indies; all told, there were twenty-two ships, thirteen of which followed the Cape route, and nine attempted the passage through the Straits of Magellan.

The first of these expeditions to reach the Indies was that of Jacob Van Neck. With eight ships and 560 men, Van Neck sailed from the roads of Texel on May, 1, 1598. Three weeks later the fleet reached Cape Verde Islands, and on July 9th crossed the equator. Van Neck then altered course to the west and sailed for Trinidad. From Trinidad he sailed to the Cape of Good Hope and there lost one of his ships in heavy weather. A few days later, through some misunderstanding, four ships became separated from Van Neck and after some time spent trying to find them he proceeded on his voyage with the remaining two large and one small vessels. A short stop was made at Madagascar to get fresh food and water and the voyage resumed. For two months Van Neck sailed steadily eastward and on November 19th the land of Sumatra was sighted. On November 26th Van Neck anchored at Bantam. He had made a much faster voyage than Van Houtman, and although many of his men had been sick, none had died.

Van Neck was favorably received by the Sultan of Bantam, who now saw in the Dutch a potential ally against the detested Portuguese. This time, the Portuguese were not able to turn the Javanese against the Dutch and the ships began loading pepper immediately. Van Neck was getting his pepper for three reals a bag (the old Spanish real varied in value from about six to twelve cents), but after some days of loading a report was spread that pepper fetched one hundred reals a bag on the Amsterdam market and the Javanese merchants demanded more money. To offset this, Van Neck tried buying from the Chinese traders, but these devils mixed sand and stones with the pepper and he was forced to discontinue business with them. He met the demand of the Javanese by raising his price to five reals a bag and loaded his ships with their pepper. While in the Indies, Van Neck also visited the Banda Islands where he obtained a part cargo of nutmegs and established a trading post.

His ships filled with spices and his business concluded, Van Neck sailed for home. On his return voyage, he lost several men from dysentery, but safely brought his three ships to Holland where he arrived July 19, 1599. There was great rejoicing among the people and merchants of Amsterdam and the spices were sold at great profit.

The other four ships eventually turned up at Bantam on December 31, 1598. Apparently they had spent several days in the vicinity of the Cape, looking for Van Neck and then, while trying to make Madagascar, had been driven eastward by a gale and came to the island of Mauritius instead. From here, they proceeded to Bantam. As no pepper could be loaded until fresh supplies arrived in Bantam, the four ships sailed to the Moluccas, where they were welcomed by the Sultan of Ternate and allowed to establish a trading post on the island. Another factory was started at Amboyna and altogether they were most successful in their negotiations with the native authorities. They obtained good cargoes of cloves, nutmegs, and mace, which they brought safely to Holland.

The Van Neck expedition had been highly successful. They made a good impression on the native sultans, opened trading stations, and generally laid the foundation for the future domination of the East Indies by the Dutch.

The spices were making history and it was a bad day for the Portuguese.

XVII. THE DECLINE OF THE PORTUGUESE AND THE RISE OF THE DUTCH IN THE SPICE ISLANDS

THE story of the spices in the 17th century is the story of the decline and fall of Portuguese power in the East and of the conflict between the Dutch and English for the mastery of the spice trade.

The effect of the voyages of Van Neck and other Dutch navigators to the East Indies in behalf of the merchants of Amsterdam was to send the price of pepper skyrocketing in England and this roused the ire of the English who determined to get into the spice trade without further ado. In 1599, a number of London merchants petitioned Queen Elizabeth for a charter which would give them a monopoly of the spice trade of the East Indies. Their application met with enough opposition from the queen's councillors to delay its progress for well over a year, but Elizabeth finally gave her assent and on December 31, 1600, the company commonly known as the English East India Company and styled "The Governor and Company of Merchants of London, trading into the East Indies" was incorporated by royal charter.

A trading expedition was quickly organized and James Lancaster was appointed to the command of the first fleet to sail to the East Indies for the new company. Lancaster sailed from Woolwich on December 31, 1600, with four ships equipped, stored, and manned for a twenty months' voyage. The fleet was delayed for several months in the Atlantic by contrary winds, storms, and calms. Scurvy attacked the crews and by the time the ships reached the Cape of Good Hope, 105 men were dead and nearly all of the others were suffering from exhaustion. Lancaster ordered his ships into Table Bay and there they were compelled to remain until the men were strong enough to resume the voyage. From Table Bay, the four ships slowly made their way eastward across the Indian Ocean, stopping at those islands which lay in their course for water and fresh food. On June 5, 1602, the fleet anchored off Achin in northern Sumatra.

Lancaster got along very well with the Sultan of Achin, who permitted him to proceed with his business and buy what spices he required. But there was not a great quantity of spices on hand; the spice in greatest supply was pepper and of this, there was barely sufficient to load one ship. This worried Lancaster somewhat, since he was anxious to get good spice cargoes for the East India Company. Therefore, while the pepper was being loaded on one of his ships, he took the other three and cruised in the Straits of Malacca. Very soon, he sighted a large Portuguese galleon which he promptly chased, captured, and plundered. Apparently it didn't matter to Lancaster where he got cargo, so long as he got it; spices were what he wanted, but other goods were worth taking because they could be profitably bartered for the more desirable pepper, cinnamon, cloves, ginger, mace, and nutmeg. Following this episode, Lancaster returned to Achin. The pepper ship was now fully loaded, so that after some festivities, he bade the sultan farewell and put his ships to sea.

The pepper ship went straight home to England; another sailed to some other part of Sumatra where she obtained a full cargo of pepper and cloves and then departed for England; and Lancaster proceeded with two ships to the island of Java and anchored off Bantam. He was well received and soon made a friend of the boy sultan, who had recently succeeded to the sovereignty. He secured a cargo of pepper for each of his ships and, while the spice was being loaded, he took the opportunity to establish a trading station at Bantam and detailed to its management and protection three of his factors and eight stout seamen. He also carefully instructed a similar group and sent them by pinnace to the Moluccas, where they were to found a factory in preparation for future English trading.

His two ships loaded, Lancaster sailed for home on February 20, 1603. They had an uneventful voyage to the Cape, but ran into bad weather in the Atlantic. Lancaster's vessel lost her rudder and for many hours his ship was in a sad plight. Fortunately, the weather abated before any serious damage was done and the crew succeeded in rigging up a jury-rudder. A call was made at the island of St. Helena for fresh food and water and on September 11, 1603, the two ships anchored in the English Downs.

The voyage had been long and risky, but the East India Company had gained a foothold in the Indies, and Lancaster's ships had brought to England enough pepper to break the Dutch hold on the market. The activities of the Dutch had forced the price of pepper to eight shillings a pound in England, and Lancaster had bought his pepper for less than sixpence a pound in the East Indies. The cloves would also bring a handsome return. We do not know what the market for cloves was at that time, but history records that a shipment of cloves purchased in the Spice Islands for £2,948 in 1606, brought the sum of £36,287 when sold in England two years later. It had been a very profitable undertaking for the new company and an encouraging start.

Lancaster was knighted in October 1603, and was given a directorship in the East India Company which he held until his death in May, 1618.

Lancaster had met the Dutch in the East Indies and found them friendly; the Portuguese, as usual, were put out. Outward bound, Lancaster had captured and plundered a Portuguese carrack in the Atlantic and this, together with his plundering of the galleon in the Straits of Malacca, gave the Portuguese an opportunity to accuse him of acts of piracy and thus generally discredit the English with the natives.

The Dutch merchants were then operating as rival groups. Their ships were out to get spices, not to battle the English or Portuguese, although they were prepared to fight whenever necessary. In 1601, they fought themselves into a share of the cinnamon trade of Ceylon and later in the same year, defeated a strong Portuguese fleet in the roads of Bantam to get a share of the pepper of that port. However, the rivalry among the Dutch had serious disadvantages: It prevented a solid front against entrenched Portuguese opposition and caused unnecessary competition for the spices of the Indies. The native traders were not slow in taking advantage of the demand and the prices of the various spices increased sharply.

The Dutch soon realized that if they were going to smash the Portuguese opposition in the Indies and attain control over the native spice producers and traders, all rivalry and competition among themselves must end. And so, like the London merchants before them, the merchants of Amsterdam promoted a company for the monopoly of the spice trade of the East Indies and in March 1602, the Estates General of the Netherlands sanctioned the establishment of the United East India Company.

The new company took over the factories already established by the Dutch merchants in the East Indies and in three years equipped and sent out thirty-eight ships in a planned effort to control the spice trade. More ships followed these. They reached out from the Indies and established trading posts at Patani and Ayuthia in Siam; drove the Portuguese out of Johore in the Malay Peninsula; took Amboyna in the Spice Islands without a struggle, and captured the Portuguese fortress at Tidore.

Then they met with some reverses. They attacked the Portuguese stronghold of Malacca in 1606, but were driven off. In the same year, a Spanish fleet from the Philippines conquered the Dutch trading posts in the Moluccas. The Sultan of Ternate came to the aid of the Dutch in the Moluccas, but the situation there remained one of turmoil. They concluded a treaty with the Sultan of Achin in 1607, which led to nothing. In the Banda Islands, where the Dutch had obtained a contract giving them a monopoly of the nutmeg trade, they had trouble with the natives who persisted in carrying nutmegs to Macassar where they sold them to the Portuguese and English. This encouraged the Portuguese and finally brought English ships to the Banda Islands, but in the resulting conflict with the Dutch the English had to withdraw.

While all this strife was going on among the Europeans and with the natives, the spice trade was suffering and prices were rising. Portuguese, English, and Dutch were vieing with one another for pepper, cinnamon, cloves, ginger, mace, and nutmeg and the native producers and traders were taking advantage of the situation to get all they could for these products. Pepper prices in Bantam reached a new high because of the competition between the Dutch and English in that port.

The Dutch were not enjoying this situation and decided to use whatever force and means necessary to get the Portuguese entirely out of the Indies, drive off the English, and obtain mastery over the Indies and the spice trade. They attempted to move their spice factory from Bantam to the neighboring city of Jacatra, with the intention of making Jacatra a fortress city and operating from there. This resulted in a naval battle with the English and conflict with the Sultan of Bantam, but the Dutch were eventually victorious and conquered Jacatra in May 1619. The Dutch garrison of Jacatra resolved to name the city Batavia, and on March 4, 1621, the Dutch East India Company confirmed their resolution and one of the world's greatest trading centres came officially into existence. From this important stronghold, the Dutch relentlessly pursued their efforts against both Portuguese and English.

In 1619, an attempt was made to reconcile the differences between the Dutch and English and the Treaty of Defense was signed. This treaty called for a policy of mutual cooperation between the Dutch and English trading companies and the maintenance of a joint fleet in their common struggle against the Portuguese. But the terms of the treaty meant little to the zealous Dutch and English traders in the Indies and differences, disputes, and fights continued between them.

In the next twenty years the Dutch pursued a policy of aggression with unbelievable cruelty. In 1621, they fiercely attacked the Banda Islands and mercilessly brought the natives under subjection. In 1623, the so-called massacre of Amboyna took place, in which eight Englishmen were tortured and executed by the Dutch for allegedly attempting to seize their fortress on that island. For years, they fought the Javanese. For three years beginning

1635, they battled the natives of the Moluccas to enforce their policy of restricted output of spices. In 1637, the Treaty of Defense lapsed.

In 1641 the Dutch conquered Malacca. The belligerent Achinese of Sumatra had opposed Dutch and Portuguese alike, but their resistance to the Portuguese had materially helped the Dutch in their attack on Malacca. It had enabled them to blockade the straits and thus seriously weaken the position of the Portuguese in their stronghold city. Nevertheless, Malacca was not easily taken. The Portuguese defended the city with great courage and fortitude and the Dutch had to go through five months of bitter fighting to overpower them. Malacca had served the Portuguese as their headquarters for the control of the Indies and the wealthy spice trade for one hundred and thirty years. Its fall was a fatal blow to them. Since the turn of the century the Portuguese hold on the Indies had gradually weakened and now it was broken.

The spices of the East had led Portugal out of obscurity into world prominence and, by the beginning of the 16th century, to the zenith of her power. The unbridgeable gulf of religious difference between the Portuguese and the native people of the East had seriously hindered Portugal in her efforts to attain a lasting mastery over the Indies and the great spice trade and had made the interference of other powers in her foreign and commercial affairs very much easier. But, as we have seen, the aromatic trail had led the Portuguese to distant parts of the world unknown to her in the days of Prince Henry the Navigator, where they had gained territorial possessions and great commercial prosperity.

In the 16th century, her affairs had become gradually entwined with those of Spain and in 1580 Portugal was incorporated in the kingdom of Spain. Spain went down to defeat and subsequent oblivion when her great Armada was smashed by the English in 1588 and Portugal gained her independence in 1640 when the Duke of Braganza, a descendant of a natural son of John I, became John IV following a successful war against Spain. But in the years between the defeat of the Armada and the advent of John IV, the struggle with the Netherlands for the control of the East Indies had crushed the life out of Portugal and her old glory was gone.

The conquest of Malacca gave the Dutch complete control of the straits and enabled them to bring pressure to bear on the Malay Peninsula and northern Sumatra. The city itself served them more as a fortress and naval base than as a trade centre since their headquarters were already established in Batavia. Dutch mastery over the Indies and the spice trade soon followed. They had a monopoly of the pepper trade of two central states in Sumatra, but a few years were to pass before they gained control of the Achinese pepper trade. The Moluccas were under their rule, with the exception of an unimportant Spanish outpost in the island of Tidore. The Banda Islands were likewise subjugated, although surreptitious trading still went on between the Bandanese and the Portuguese and English at Macassar. Batavia was strongly fortified and became a dominant factor in the island of Java.

From the Dutch headquarters in Batavia, a directive was issued affecting the cultivation of clove and nutmeg trees in the East Indies. On all islands, except those of Amboyna and Ternate in the Moluccas and the Banda group, clove and nutmeg trees were ordered extirpated. This wilful destruction of trees, which require years to bring their spices to fruition, reduced the production of cloves, nutmegs, and mace to one-fourth of that before the coming of the Dutch to the Indies. This was the Dutch method of creating a scarcity of these fragrant and highly desirable spices to force their prices up in the European markets for the benefit of the directors and shareholders of the Dutch East India Company.

During all this time, the rivalry between the Dutch and English for spice trading ports outside of the East Indies was equally keen. In 1622, the English successfully ousted the Portuguese from the island of Hormuz in the Persian Gulf, but spices bound for the Middle East by way of the Persian Gulf were a matter of equal importance to the Dutch. By 1632, the Dutch had established themselves at Bandar Abbas on the Persian mainland not far from the island of Hormuz and were carrying on a prosperous trade in pepper, cloves, nutmegs, and other spices with all Persia. By 1639–40, they were the dominant spice traders in the Persian Gulf.

Early in the 17th century, both Dutch and English had struck out for the spice trade into and out of China. In 1622, the Dutch unsuccessfully attacked the Portuguese possession of Macao. Later, they obtained a foothold in the island of Formosa, but did not remain long: Koxinga, the Chinese pirate and terror of the China Sea, wanted Formosa for himself and he attacked their forts and ousted them from the island. The English were more successful in their relations with China and the English East India Company's ships traded quite early with that country. In 1637, five English ships discharged cargoes in Canton and in later years profitable trade was carried on with China and possessions were gained for the crown.

In 1642, Anthony Van Diemen, Dutch governor-general of the East Indies, sent Abel Tasman to sea to explore land which had been reported by other navigators as lying southward. Tasman sailed along the coast of a great cotinent and landed on an island which he called Van Diemen's Land; farther on, he discovered two islands which he called New Zealand. But there were no spices in these places and the Dutch East India Company wasn't particularly interested. In this way, the aromatic trail led to the discovery of Australia and New Zealand.

The importance of the Cape of Good Hope as a calling place on the long route to and from the East was not overlooked and in 1652 a Dutch colony was founded there.

The spice trade of southern India was second in importance only to that of the East Indies and the Dutch were not inactive there. The foothold they had gained in Ceylon in 1601 had been gradually strengthened and extended until, with the capture of the Portuguese port of Jafnapatam in 1658, they secured control of the island and its rich cinnamon trade. In 1663, they conquered Cochin and Cannanore and a year later, they were masters of all the chief pepper ports of the Malabar coast.

Back in the East Indies, the Dutch obtained a protectorate over three native districts on the west coast of Sumatra in 1663, which had the effect of breaking the power of the Achinese in northern Sumatra. In the same year, the Spaniards withdrew from the island of Tidore. The Sultan of Tidore capitulated to the Dutch in 1667. In 1668, after months of hard fighting, the Dutch conquered Macassar, which gave them control of the Straits of Macassar and the spice trade of the island of Celebes. By 1680, the Dutch had control of the Achinese pepper trade in northern Sumatra and in 1684, they conquered the important spice center of Bantam in the island of Java. The English had maintained a spice factory at Bantam for many years, but were driven out during the Dutch attack and went to Benkulen on the west coast of Sumatra; here, an English factory was maintained for one hundred and fifty years.

Conflict continued between the Dutch and English on the island of Borneo, where both companies had operated spice factories since early in the 17th century. The two-faced dealings of the native rulers and the savage stubbornness of the people made trading very difficult on this large island for both Dutch and English and neither was able to gain the upper hand.

The 17th century closed: The Portuguese crushed; the English left with but a remnant of the spice trade; and the Dutch the undisputed masters of the East Indies, reaping the wealth of a great spice monopoly.

The demand for Eastern spices had steadily increased in Europe and the trade was perhaps the most profitable in existence at that time. The number of uses for the spices in flavoring food and beverages, in medicine, cosmetics and perfumery had multiplied. Spices were sought after by all who could afford them. As in ancient times, the spices made treasured gifts between people. They were also sometimes presented to state dignitaries on special occasions and in festive seasons; offered as political bribes; given as bonuses to the dockworkers who unloaded the spice ships; bequeathed in wills; and used as rent. The term "peppercorn rent" means today a nominal rent, but in those days it represented real value. Cinnamon was perhaps the most desired of all the fragrant spices, particularly the bark grown in Ceylon which had a value on the European market many times that of the Malabar product, or the cassia of the Far East. The trade in this spice was one of the most profitable of all to the Dutch East India Company, which did not hesitate to burn large quantities of the bark to keep its price high. Not only had the trading companies profited handsomely from their ventures into the East Indies, but the revenues of their respective countries had been materially increased by the import and export of pepper, cassia, cinnamon, cloves, ginger, turmeric, mace and nutmegs.

XVIII. THE DUTCH AND ENGLISH IN THE SPICE ISLANDS

HALFWAY through the 18th century, the tide of fortune began to change for the Dutch East India Company. There were many reasons for this, but the principal were the steps taken by the French and British to break the Dutch monopoly by introducing spice plants into their own overseas colonies, the loss of Dutch possessions in India, the export of spices from India by the English East India Company, the British blockading of Dutch East Indian ports, and piracy and smuggling in the waters of the Indies.

The Dutch had angered Europe by making her pay dearly for cloves, nutmeg, mace, and cinnamon through their rapacious policy of curtailing production and creating artificial scarcities of these commodities. For a hundred years they had enjoyed naval supremacy in the Indies, and kept the foreigners from their spice-trading ports. But monopolies of this kind can be very harmful to the monopolists.

A few French trading vessels had found their way to the East Indies early in the 17th century. In 1664, Jean Baptiste Colbert, the most powerful statesman in the government of Louis XIV, organised a French East India Company which by royal edict was to enjoy a monopoly of all trade between the Cape of Good Hope and the East Indies, but its fleet was not capable of rivalling that of the Dutch company and it made no headway whatever into the spice trade during its short life. However, the French, determined to break the Dutch monopoly of fragrant spices, in the latter half of the 18th century, despite Dutch vigilance, managed to spirit clove, nutmeg, and cinnamon plants out of the East Indies and introduce them into the islands of Reunion, Mauritius, and Seychelles in the Indian Ocean, and French Guiana in South America.

The English East India Company, following its unsuccessful attempts to get hold of the spice trade of the Indies, concentrated its efforts in India. The Indian ports, which the Dutch had occupied in the latter half of the 17th century, were lost to the British in the 18th century. The Malabar coast produced pepper, ginger, and cinnamon and the English East India Company exported these spices in large quantities to the detriment of the Dutch company.

In 1780, Holland became involved in a war against England, which resulted in near bankruptcy for the Dutch East India Company. British ships blockaded Dutch East Indian ports and cut off communication between Batavia and Holland. Spices piled high in Batavian warehouses and the Dutch could not turn them into much needed money. During this period, piracy and the smuggling of spices out of the Indies became rampant—and to the Dutch, costly.

The British occupied the Malayan island of Penang in 1788 and about eight years later, they successfully transplanted clove trees from the Moluccas into the island.

The increasing strength of the British was too much for the Dutch, who were now thoroughly weakened in the Indies and unable to get assistance from home. In 1795, the British attacked and conquered Malacca and a year later were in possession of all Dutch territory and trading posts in the East Indies, except Java. In 1796, the English East India Company made territorial gains in Ceylon and obtained a share of the cinnamon trade of that island. And in 1799, the Dutch East India Company was dissolved. The affairs of the Company were taken over by the Dutch government.

The Dutch East India Company had been a progressive and powerful factor in the colonizing and trading affairs of the Netherlands for almost two hundred years; at the height of its prosperity, in 1669, the Company had one hundred and fifty trading ships, forty ships of war, one thousand soldiers, and paid a dividend of forty per cent.

From two Dutch navigators, Beeckman and Stavorinus, we get an interesting picture of the spice trade of the Indies in the 18th century. Beeckman, on a voyage to Borneo early in the 18th century, noted that a people he calls the Banjareens "have white pepper, which is commonly sold for twice the price of black. They tell you that it is made white by a certain bird, which they call *Ballaree*, that lives on black pepper, digesting nothing but the hull, and dunging but the substance, which through this means becomes white, and is gleaned up by the poor people, from whom we always bought it by very small parcels at a time." This must remind you of the stories told by Herodotus and other writers of antiquity to explain the presence of cassia and cinnamon in Arabia. It seems the people of Borneo in the 18th century were as shrewdly deceptive as the Arabs had been two thousand years before in protecting their trade secrets!

Beeckman tells us that they also resorted to adulteration and mixed stones and dirt with the pepper.

Stavorinus, on a visit to the Indies much later in the same century, tells us that the chief product of Java is pepper, and that it is grown in the western part of the island. He describes the pepper plant as a vine, training its tendrils around poles or trees as ivy or hops would do, with the peppercorns growing in bunches close to each other, at first green and then black. When the peppercorns are dried, he says, they are first separated from dust, and "partly from the outward membranous coat, by means of a kind of winnow, called a harp, and then laid in warehouses. This winnow, or harp, is an oblong frame, with a bottom of iron wire closely twisted, so the peppercorns cannot pass through it; this is set sloping, and the ungarbled pepper rolling along it frees itself from most of its impurities."

Lampong pepper of Sumatra, he tells us, was esteemed the best next to that produced on the Malabar coast of India. White pepper, he explains, was manufactured by placing black pepper, not perfectly dry, in lime, "which takes off its outer coat, and renders it whitish."

In Amboyna, Stavorinus relates, the cloves were in such abundance that the Dutch authorities at Batavia sometimes ordered a large number of clove trees to be extirpated and fixed the number of trees that should be in production:

> Thus, by a resolution of the year 1768, they ordered that the propagation of the clove trees should cease till their number was reduced to 550,000; the number of trees both young and fruit bearing was then 759,040.

According to this navigator, at the time of his voyage to the East Indies there were 3,000,000 pounds of cloves in the Dutch warehouses at Batavia, of which not more than 200,000 could be disposed of annually in the Indies. In addition to the cloves stored in Batavia, there was enough stock of the spice in Holland to meet the needs of Europe for ten years. Such an abundance of cloves was a threat to the handsome market the Dutch strived to maintain and, consequently, large quantities of cloves were "committed to the flames," from time to time by the Dutch East India Company.

Similar conditions existed in nutmeg production and quantities of this spice were also periodically destroyed by fire to maintain the Dutch monopoly.

The nineteenth century brought farther penetration of Ceylon by the English East India Company, resulting in the island being constituted a British crown colony in 1802.

Under the terms of the Treaty of Amiens, signed March 27, 1802, all territories in the Indies were restored to the Dutch, but they did not have them long. In the month of February 1810, an English naval squadron arrived in the Spice Islands and captured the clove islands of Ternate and Amboyna, and the nutmeg islands of the Banda group. In the year 1811, Lord Minto, then governor-general of India, equipped a fleet which sailed to the Indies and captured Batavia. However, under the agreements reached at the Congress of Vienna 1814–15, the Dutch possessions in the East Indies were retroceded to the Netherlands and in 1824, all questions at issue between England and the Netherlands were settled by treaty. In this year, the port of Malacca, which had been restored to the Dutch in 1818, was ceded to the British in exchange for Benkulen and other places of lesser importance on the west coast of Sumatra.

During these years further steps were taken by France and England to produce spice plants in lands under their domain. In 1818, the clove tree was introduced into Zanzibar from Mauritius and its cultivation was so successful that today Zanzibar and the adjacent island of Pemba produce by far the greater part of the world's supply of cloves. Later, the nutmeg tree was successfully introduced into the West Indies. These efforts, togetheer with the conquests of the British, completely destroyed the Dutch monopoly of spices in the East Indies.

The conflict between the Dutch and English in the island of Borneo ended in 1892, when the two countries reached an agreement on territorial boundaries. The excellent Sarawack pepper found in the spice markets of today is a product of the state of that name in British Borneo. The pepper of Borneo is mainly shipped through Singapore, an important spice-trading center which came into the hands of the British, when the English East India Company took over the island of Singapore in 1819.

The English East India Company, as we have already said, concentrated the greater part of its colonizing and trading efforts in India and acted for the British government in that country until 1858, when parliament took over the control of the political affairs of India. The Company was dissolved in 1874, after two hundred and seventy-four years of empire building, founded on the search for the fragrant spices of the East in the days of Queen Elizabeth.

In the latter part of the 19th century, the Dutch had considerable political trouble in the East Indies, including the bitter thirty years' war with the Achinese which began in 1873 to establish Dutch mastery in Northern Sumatra. This war is said to have taken a toll of a quarter million lives, besides costing an incredible sum of money.

The 20th century brought further difficulties for the Dutch in the East Indies. Following the First World War, agitation was rife among the

Indonesians and violence flared in Java and Sumatra. The great depression brought enormous economic losses and the Japanese did all in their power to enter the economic sphere of the islands. In the Second World War the East Indies were successfully invaded by the Japanese. Following the defeat of Japan, the unrest among the Indonesians, which received considerable impetus from the Japanese conquest of the Dutch, broke into open rebellion. Out of this came the Republic of Indonesia.

It is now four hundred and eighty years since Bartholomew Diaz doubled the Cape of Good Hope in the search for an all-water route to India, so that Portugal might wrest from the Moslem traders, the Sultan of Egypt, and the merchants of Venice the profitable spice trade of the Orient. And we have seen how greatly this spice trade has shaped the course of history since that time. It is difficult for us, who buy our supplies of pepper, cassia, cinnamon, cloves, ginger, mace, and nutmeg so casually and so cheaply, to believe that there was ever a time when these spices were so eagerly sought after and represented so much wealth and power that destiny itself was indivisible from them.

XIX. AMERICA ENTERS THE PEPPER TRADE

IN the 17th and 18th centuries while the Dutch and English were contending for control of the spices of India, Ceylon, and the East Indies, thousands of immigrants from the Old World were busily building a new society in America. Capable, industrious, and enterprising, they steadily overcame the hardships of pioneering a new way of life and engaged in all forms of industrial activity from fishing and shipbuilding in the north to raising tobacco in the south. Trade and shipping developed to a point where, to quote Beard[*], "When George III ascended the throne in 1760 American merchants and shippers in the great colonial ports were numerous enough, rich enough, and powerful enough to vie with the stoutest merchants of Bristol and London." One of these ports was Salem, Massachusetts.

Salem had become a well-known port and her ships and sailors were as good as any in the world. Starting out with cargoes of New England products, Salem navigators took their ships to ports in the West Indies, in Africa, and by 1786 in the Indian ocean and the Far East, trading and bartering as they went and returning home laden with profitable eastern merchandise.

According to *Merchant Sail*[**] the ship *Grand Turk*, under command of Captain Ebenezer West, sailed December 3, 1785, for Ile de France (Mauritius) "and points beyond," and was the "first Salem vessel to round the Cape of Good Hope and to visit Canton or any Chinese port." Salem navigators in far eastern waters would be aware of the lucrative spice trade of the East Indies but because of Dutch and English control, influence, and vigilance it would not be possible for them to obtain spice cagoes in the regular trading ports of those islands. If they were going to get a share of this trade they would have to seek it in the more remote parts of the Indies.

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[*] *A Basic History of the United States*, Charles A. Beard and Mary R. Beard, The New Home Library, New York, 1944, p. 43.

[**] *Merchant Sail*, William Armstrong Fairburn, Fairburn Marine Educational Foundation, Inc. Center Lowell, Maine. vol 5, p. 3009.

The first of these navigators to succeed in such a venture was Captain Jonathan Carnes, sometimes called the "Father of the American spice trade." It is related* that Carnes while in the port of Benkulen in 1793, out in southwestern Sumatra, heard talk to the effect that pepper grew wild and was procurable on the northwest coast of the island.

Carnes, evidently a sagacious and enterprising trader, alert for an opportunity to obtain a spice cargo, would make quiet and discreet inquiry of the natives. Without a backlog of knowledge on the navigation of the local waters of northern Sumatra, anything he could learn of the navigation hazards, the location of bays, inlets and harbors for safe anchorage would be of value. In Benkulen, at that time, the English had a spice factory. They had been there for a century before Carnes' time. Carnes would, no doubt, gather all the information he could about their activities and the range and extent of their influence north of Benkulen.

He would also gather what information he could on the activities of the Dutch in northern Sumatra, although they would not be great at that time. The Dutch were being hard pressed by the English. As we have seen, Dutch-held Malacca fell to the British in 1795, and a year later all Dutch territory and trading posts in the East Indies came under British control.

He would take into account the risks from pirates frequenting the waters of northern Sumatra. And he would decide how best to deal with the wily native chieftains with whom he would have to trade. Pepper wasn't just growing wild in northern Sumatra waiting for the crew of some adventurous foreign ship to come ashore and strip the berries from the vines. On the contrary, the pepper of northern Sumatra had been an item of trade as far back as the early part of the 16th century.

Carefully weighing the information and assessing the possibilities, he evidently concluded that the chances were good that a pepper voyage to northern Sumatra could be safely and successfully accomplished. It was worth a try.

On his way home, Carnes would turn the idea over and over in his mind, plan his action, and plot his intended course. But such a voyage would have to be financed and to this end, on his arrival in Salem, he approached a prosperous merchant of that port by the name of Jonathan Peele.

Peele would not require much convincing. In his capacity and experience you can be sure he would be fully aware of the profits that had been made by European traders out of the spices of the Far East. Here was an opportunity to gain a foothold in this gainful trade. It was indeed worth a try. And so, in the schooner *Rajah*, a vessel of 130 tons with four guns and a crew of ten men, fitted out by Peele, Captain Carnes slipped quietly out of Salem on a trading voyage to the Far East, November 1795. His cargo consisted of brandy, gin, iron, tobacco, and dried fish.

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* *Ibid.* vol 1. p. 529

The *Rajah* was away a long time and there were those who feared disaster of some sort or another had overtaken ship and crew. But whatever storms, hardships, or trials were met they were evidently successfully overcome because eighteen months after clearing Salem she dropped anchor in that harbor with a full cargo of Sumatran pepper. "This unique cargo, costing some $18,000 with expenses, sold for 700 per cent profit at Salem. Ralph D. Paine, the Salem historian, says that the return was 'at least seven hundred per cent of the total cost of the vessel and voyage; in other words this one adventure of the *Rajah* realized what amointed to a comfortable fortune in that generation.' "*

In respect to dates given above there appears to be some difference of record in the light of the following information given in *Merchant Sail*: "Captain Jonathan Carnes, of Salem, is generally credited, most properly, with opening up the United States-Sumatra pepper trade. He took a Salem schooner out from Salem to the East Indies in 1795 and learned much of the possibilities of obtaining pepper in northwest Sumatra. His vessel was lost on a reef in the West Indies when returning home, but upon his arrival at Salem, Captain Carnes induced Jonathan Peele, a wealthy distiller of Salem, to fit out a 120-ton schooner built at Salisbury in 1795 and re-rig her as a brigantine. The historic *Rajah* was registered July 14, 1798, with Willard Peele and Jonathan Peele as owners and Jonathan Carnes, master. The *Rajah* sailed to Sumatra on July 20, 1798, as the pioneer pepper trader and returned October 15, 1799, with a cargo of 158,544 pounds of pepper. It sold in Salem for 37 cents a pound, which gave a profit of 700 per cent on the cargo. (The duty paid on pepper was $9,512.64.)"**

Just as Lisbon had rejoiced when Vasco da Gama returned from Calicut with news of the abundance of cinnamon, ginger and pepper in southern India, and of the spices that came to Calicut from the eastern islands, so did Salem react to the good fortune of Captain Carnes. There wasn't a merchant or shipowner worth his salt who didn't want to get his share of such a profitable trade and who wasn't prepared to try. But it wasn't that simple. Captain Carnes had pioneered the pepper route to northern Sumatra and only he knew where to go to get another cargo. That Carnes had been to

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* *Merchant Sail*, Vol. 1, p. 530.

** *Ibid.* vol. 5, p. 3009

Benkulen was known to his rivals but not more than this. A dozen ships hurriedly fitted and sailed for Benkulen hoping to duplicate the success of Carnes in obtaining pepper, but without his local knowledge they were unable to find a source of supply.

Jonathan Carnes readied his ship for a second voyage to Sumatra. His activities were not unnoticed and when he sailed his ship was not alone. Other Salem vessels followed in his wake and came to anchor with him in Benkulen, no doubt feeling confident that Carnes would lead them to his pepper source if they just kept an eye on him. But they were not vigilant enough, it seems, for Captain Carnes stealthfully slipped out of the harbour and managed to elude them. Carnes reached his source of supply and *Rajah* returned to Salem July 18, 1801, with "147,776 pounds of pepper and paid duty of $8,938.46."*

Following the second voyage, the Peeles sold the *Rajah* to other Salem owners, but Captain Carnes made no further voyages in the historic vessel. *Rajah* again changed hands in August 1803, and was bought by New York owners in 1804.

Captain Carnes died December 10, 1827, aged 70 years. To give this accomplished and courageous mariner full honors perhaps we should relate the following. He was, according to old Salem records, "one of the earliest navigators to the East Indies. In 1788 he commanded the brig *Cadet*—the first vessel to visit the west coast of Sumatra."**

One William Vans, who had been supercargo of the *Grand Turk*, says in his biography, written and published in 1832, that he fitted out the brig *Cadet* in Boston and that this was "the first vessel from America to Bencoolen, Moco, Paddang, Tappannooly, and other ports on the west coast of Sumatra, where I bought cassia, cinnamon, gum benzoin, pepper and other goods, and opened a trade with that island, which has been so beneficial to the United States, and particularly to the town of Salem."† It would seem that the claim rightly belongs to Captain Carnes. The *Cadet*, according to the Salem records, was under the command of Captain Carnes, and William Vans was probably shipped as supercargo.

Following the second voyage of the *Rajah* the source of the pepper supply in northwest Sumatra became known and the great American pepper trade with that island began. Ship after ship sailed for Sumatra and returned with cargoes of pepper. "According to customhouse records, some two hundred 'pepper vessels' entered Salem between 1795 and 1845."* Some of the more notable voyages include the *Concord* which brought to Salem November 16, 1803, 261,937 pounds of pepper, paying duty of $15,727.40. The *Belisarius* arrived in Salem July 28, 1801, with 336,937 pounds of pepper, paying duty of $20,357.16; a year later she brought home a similar cargo on which the duty was $20,916.40; on September 20, 1803, she reached Salem with 295,824 pounds of pepper on which duties of $17,749.44 were paid. The *America* brought to Salem, November 6, 1801, 844,918 pounds of pepper and paid $56,348.82 duties; the following year she returned to Salem on October 9, with 760,000 pounds of pepper and paid $50,031.70 duties. The *Cincinnatus* arrived in Salem September 11, 1803, with 307,824 pounds of pepper; and in November 1807, she came home with 347,000 pounds of pepper. The *Janus* brought to Salem in December 1809, 537,989 pounds of pepper; and in December 1810, 547,795 pounds. The *Franklin* reached Salem in September 1810, with 539,835 pounds of pepper.**

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* *Merchant Sail*, vol. 5, p. 3009

** *Ibid.*

† *Ibid.*

So great was the pepper trade that in 1805 the United States exported 7,559,224 pounds of pepper to European ports, a large proportion of which was landed in Salem.†

Not all pepper from the northwest coast of Sumatra came to Salem but this Massachusetts port was the chief pepper center. There the trade began and was vigorously carried on until 1850. Salem was the emporium of the American pepper trade for fifty years, and just as spices had brought great wealth to other places and traders in other times so they had to Salem and its merchants.

Trading on the northwest coast of Sumatra had not been without its difficulties and dangers to the American ships, as, for example, when the *Friendship* was boarded and plundered by Malaysians and a number of her crew taken prisoners, incapacitated, or killed.††

With the passing years there was growing native hostility and unrest in northern Sumatra. To whatever effect this may have had, there was added the frequent raiding of the American ships by pirates. For centuries pirates had infested the waters of the South China Sea, the eastern Indian Ocean and the waters of the East Indies. They prayed upon native junks and other vessels in coastal waters and becoming bolder and bolder did not hesitate to attack the trading ships of the west regardless of flag. In this way, many American ships were raided, plundered and destroyed, and many an American seaman died from a swift stroke of a knife in the hand of a thieving, bloodthirsty pirate.

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* *Merchant Sail*, vol. 1, p. 530

** *Ibid*, vol. 5, pp. 3009, 3010.

† *Ibid*, vol. 1, p. 530

†† *Ibid*, vol. 1, pp. 530–32.

In 1818 Benkulen was restored to the Dutch. It was inevitable that they would again seek control of the northern Sumatra spice trade and perhaps it is not unreasonable to suspect that the native hostility which the Americans met in later years was a reflection of the unrest brewing between the natives of northern Sumatra and the Dutch.

The growing struggle in Sumatra terminated in the long and devastating war between the Dutch and the Achinese of northern Sumatra which began in 1873, and in that year the American pepper trade with that island came to an end. Hundreds of successful voyages had been made to the East Indies to bring the pepper of Sumatra to the shores of the United States. It was a great accomplishment and a credit to the sagacity and enterprise of American merchants and shipowners, and to the intrepid navigators and the staunch sailors who endured the hardships of seafaring in those days, the storms and perils of the sea, and the murderous onslaughts of the despicable characters who roved the eastern waters.

XX. USES OF SPICES IN THE MODERN WORLD

IN the passage of time, the uses for the spices have steadily increased. They have become indispensable in the culinary art, adding savor to insipid dishes, tang to beverages, and zest to appetizers. Numerous new dishes have been made possible because of the aromatic and pungent spices. One well-known modern cook book lists 42 recipes for hors d'oeuvres, cocktails, and appetizers; 55 for soups; 131 for fish dishes; 278 for meat, game, and poultry dishes; 216 for pickles, sauces, dressings, and stuffings; 131 for vegetables; 33 for cheese dishes; 46 for macaroni and noodle dishes; 31 for egg dishes; 22 for salads; 11 for sandwiches; 320 for puddings, desserts, cakes, cookies, pastries, breads, and preserves; and 47 for beverages, in which spices are an essential ingredient.

Pepper is the leading culinary spice and in the order given here, other spices follow in importance in the preparation of modern dishes: cinnamon and cassia, capsicum spices, cloves, allspice, parsley, mustard, nutmeg, celery, ginger, aniseed, laurel leaves, mace, garlic, sage, mint, thyme, curry, marjoram, cardamom, caraway, savory, turmeric, coriander, dill, fennel, cumin, basil, rosemary, and fenugreek. They are used in the whole state or ground, depending on the requirements of the dish.

In the food manufacturing industry, the spices have a most important place. In modern times the industry has made available to the public a great variety of cooked and semicooked foods, pickles, sauces, relishes, dressings, conserves, and confections, from soups to candies, which depend on spices for flavor. Among the flavoring extracts, there are many made from the essential oils of the spices, including anise, basil, cassia, cinnamon, celery, cloves, ginger, nutmeg, savory, star anise, mint, marjoram, and thyme.

The spices, or their volatile oils, are not less important in the manufacture of liqueurs and cordials. Innumerable uses for the fragrant spices have been found in this industry since the preparation of the spiced wine of Solomon's day. Today, aniseed, star anise, coriander, fennel, cloves, nutmegs, laurel leaves, mint, ginger, and cumin, all find use in the making of a long list of beverages including absinthe, curacao, chartreuse, benedictine, crème de noyau, kummel, anisette and gin.

The perfumery and cosmetic industry employ the oils of many spices, including allspice, caraway, cinnamon, cassia, cloves, nutmeg, mace, rosemary, and cardamom in the blending of volatile and fixed oils to make dozens of alluring perfumes far in advance of the crude scents of the ancients. These fragrant oils are essential to the preparation of many sachets, toilet waters, powders, pomades, and hair oils.

Many other industries find the spices or their oils necessary in the production of their products, for example, the soap industry and the manufacturers of toothpastes and powders.

The present countless and diversified uses for the spices and their oils have grown out of the few and simple applications of the spices to the needs of the ancients. The growing population of the world, the exchange of ideas, the discovery of new lands, the increased production of spices, and the growing needs of society have steadily developed the modern uses for the spices through the passing centuries. The same factors have largely destroyed the ancient and medieval beliefs in the medicinal and romatic virtues of the spices. There are still some who cling to the ancient beliefs about the spices and who attribute to them healing powers that are almost as fantastic as those of ancient times.

Modern pharmacopoeias are cautious in attributing medicinal effects to the spices. The wild claims of the ancient and medieval physicians and herbalists find no place in present-day materia medica. Today the principal uses for the spices in medicine lie in their adjuvant and alleviative qualities. Some of the spices have bactericidal and fungicidal properties which find a useful place in modern medicine.

Aniseed is considered a mild carminative and may be used in flatulent colic. Its oil is sometimes used as an expectorant and has also been recommended as beneficial against body lice. Allspice is chiefly employed as an adjuvant and sometimes as a stomachic. Cinnamon and cassia are adjuvants and have stomachic, carminative, astringent, and stimulant qualities. The oil of cinnamon is a powerful but irritant germicide and rarely used in medicine. Cloves are employed chiefly to modify or assist the action of other medicines, but also as a stomachic and carminative. The oil of cloves is an active local anesthetic and a powerful germicide. Caraway is a mild stomachic and carminative; its oil is sometimes used in the treatment of scabies. Cumin seems to have no medicinal uses. Cardamom is employed chiefly as an adjuvant; its oil is not used medicinally. The therapeutic value of celery is doubted. Dill and fennel are mild carminatives. Fenugreek finds use only in veterinary medicine and is usually an ingredient in "condition powders" for cattle.

The capsicum spices, unknown to the ancients, have perhaps a wider use in medicine than any other. They are employed as rubefacients, stimulants, stomachics, and carminatives. Among other internal uses, they have been found beneficial in cases of atony of the stomach. Externally, they have proved helpful as stimulants in treating lumbago and other muscular affections.

Garlic, as we have seen, was credited by Pliny and the physicians of antiquity with innumerable cures, but today it is considered useful only in cases of bronchitis, coughs, and colds. Ginger is a good stimulant and carminative. Laurel leaves have no uses in medicine, but the oil extracted from the leaves is sometimes employed in the treatment of rheumatic joints. Mint is an aromatic stimulant; the oil of peppermint is said to be useful in increasing the flow of bile and has also been recommended in the treatment of gallstones; the oil of spearmint is a carminative. Mustard is an emetic, but its most important use is as a rubefacient. Nutmeg and mace are of very little value to medicine; the essential oil is sometimes used as a local stimulant to the gastro-intestinal tract and may have some value as a nerve sedative. Marjoram, origanum, poppy seeds, parsley, and sesame have no therapeutic value. The fixed oil of seasame seeds is sometimes employed as an emollient. Onion is employed occasionally in subacute bronchitis as an expectorant. Black and white pepper find use as carminatives and rubefacients. Rosemary has no medicinal uses, but its essential oil is a carminative and sometimes an ingredient in rubefacient liniments.

Sage, which was so highly esteemed in medieval times for its medicinal uses, is said today to be merely a feeble aromatic, slightly carminative and astringent. Thyme is a stimulant, diaphoretic, and carminative, useful in the treatment of bronchitis and whooping cough. Its oil is an excellent bactericide and fungicide. Turmeric is sometimes employed to add color to ointments and its oil is said to be useful in the treatment of gallstones. Saffron has no therapeutic value.

In summary, the spices or their essential oils are useful for imparting a pleasant taste to otherwise disagreeable medicines and in aiding the effect of the chief ingredient of a medicine. Internally, some are beneficial in cases of flatulence and colic; in lozenges, for the alleviation of coughs and pharynx complaints; as expectorants in chest trouble; as stimulants to excite languid stomachs; and as emetics. They are also helpful in cases of gastritis and dyspepsia. Externally, some spices are of value in treating rheumatism, lumbago, neuralgia, bronchitis, and similar obdurate complaints. The antiseptic properties of cloves and thyme have a place in mouth washes and throat sprays to check the spread of pathogenic bacteria.

EPILOGUE

THE first trade in spices would be no more than the exchange of useful herbs between neighboring groups of people, and this would take place wherever community life was found. The earliest trading in fragrant herbs probably took place in Mesopotamia, the cradle of civilization. The word "Mesopotamia" means "between the rivers," and ancient Mesopotamia was the alluvial valley between the Euphrates and Tigris rivers. Here the soil was very fertile, and the region yielded enormous crops of grain, fruit, and vegetables. Over two thousand four hundred years ago, Herodotus, the Greek historian, said of Babylonia:

> . . . but in grain it is so fruitful as to yield commonly two-hundred-fold, and when the production is the greatest, even three-hundred-fold. . . . As for millet and the sesame, I shall not say to what height they grow, though within my own knowledge; for I am not ignorant that what I have already written concerning the fruitfulness of Babylonia must seem incredible to those who have never visited the country. The only oil they use is made from the sesame-plant.★

In this land, so richly endowed by nature, it is to be expected that early man made most progress in the cultivation of crops of grain and patches of fragrant herbs. In the beginning, choice herbs would be planted near habitations—early man anticipating Pythagoras who 2,500 years ago urged, when speaking of the virtues of anise, that as much as possible of the herb should be planted near the house. As community life grew and the handiwork of men assumed the semblance of arts and crafts, some would specialize in the production of aromatic plants and substances.

When men found their way from one community to another and intercourse between neighboring lands became established, spices would be among the first products bartered and exchanged. From this stage, the spice trade would grow in importance with the development of human society

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★ *The History of Herodotus*, book I.

and the aromatics of one part of the East would find their way to another, much in the manner of the spices borne on the backs of the camels of the Ishmaelites who were trading between Gilead and Egypt in the time of Joseph.

By accident or neglect, if not intention, it would be early discovered that aromatic herbs dried in the hot sun retained their fragrance and, when crushed in the hand, imparted their scent to the skin. This would be a step toward the process of drying and baling the spices for transport and to grinding. The first spice mill would consist of nothing more than a flat stone on which the spices were pounded by a round or oval stone held in the hand. Later, the mortar and pestle would come into existence, perhaps first among the apothecaries who prepared the scented unguents and oils. Stone grinding mills followed and these, together with the mortar and pestle, have survived the passing ages. Today, the pharmacist is the principal user of the mortar and pestle, but this ancient means of crushing spices is still employed by some Chinese dealers who sell small quantities of whole spices and pound them in the mortar on request of the customer.

It is not difficult to visualize the dusky spice merchants, their camels resting in the background, bargaining with groups of buyers in the market squares of ancient Middle East towns and cities. To ancient eastern people, spices were so necessary in food, medicine, toilet requisities, and religious ritual that the trade would find difficulty in supplying the demand and for this reason, merchants pushed far afield in search of aromatics.

With the passing years and the growth of sea communication between Asiatic countries, the spice trade became more and more important and profitable. By the time the wily Arabians we're concealing their lucrative traffic in cassia and cinnamon behind fantastic stories, the spice trade was firmly established, and spice merchants were men of wealth and power. Camel trains laden with spices later travelled the length of Asia and every community had its spice vendor with his stocks of aromatic leaves, fruits, seeds, barks, and rhizomes. In past chapters, we have seen how great this trade became by land and sea, bringing fabulous riches to eastern princes and merchants.

In the early centuries of our era, the spice trade between eastern Mediterranean ports grew rapidly in importance. The international merchants of Alexandria thrived for centuries on this trade and in the Middle Ages, the merchants of Venice became rich and powerful from their commerce in spiceries. The demand for eastern spices increased all over Europe and the Venetians were the undisputed masters of the spice traffic flowing from the East through the Mediterranean into Europe. Their shrewd trading representatives were in every spice emporium from Alexandria to Constantinople, from the Red Sea to the Persian Gulf, buying spices at low prices to be piled in Venetian warehouses and sold to European buyers at handsome profits.

Spices went by a route through Switzerland to northern Europe, and by water to western Europe and England. The merchants of the Hanseatic League distributed the spices in the countries of northeast Europe. Cloves, nutmeg, mace, ginger, pepper, and turmeric appeared in the medieval town markets throughout Europe. Travelling vendors of eastern spices appeared in the great fairs. With the rise in Europe of the Merchant Guilds and the Craft Guilds, the orderly marketing of goods by local tradesmen became the custom and the travelling merchants and fairs largely passed away. Groups of people doing the same kind of work, or selling the same kind of goods, formed themselves into guilds and the spice merchants were among them. In England, the Spicers of Sopers Lane organized the Pepperers Guild in the 12th century and from then on, the spice industry in the country was definitely established. This first guild gave place to a second, organized in the 14th century, which later became the Grocers Company. By the time the western Europeans were seeking a route to the eastern spice lands that would free them from the bondage of the Venetian and Middle East spice merchants, the spicers of Europe were an old established trade. Their principal customers were members of the nobility, the class of wealthy merchants and industrialists, and the church. The poor people could not afford the luxury of imported spices, but had to content themselves with the cheaper spice products native to Europe.

We have seen how the spice monopoly enjoyed by the Venetians aroused the Portuguese and led them to seek an all-water route to India and the Far East. And we have read of their success and of the successes of Spain, England, and Holland, who followed them. So great was the European demand for spices and so profitable the trade that the spice industry grew in national and international importance and shaped the very course of history. The Portuguese organized no trading company, but exploited the spice lands as a royal undertaking; the English, French, and Dutch, all founded trading companies. The French company survived but a short time and, comparatively speaking, accomplished nothing worthy of note; the English and Dutch companies survived for many years and made history. Monopoly was the essence of their undertakings and the Dutch East India Company was the more aggressive monopolist of the two; they were far more successful in the East Indies than were the English and they ruthlessly battened down the spice trade in those islands. They reduced the population of the Spice Islands, extirpated thousands of spice trees, and burned tons of spices to secure their monopoly. During those years, fortunes were made from the sale of spices in the Amsterdam and London markets and the spice industry was at the peak of its prosperity. Factors and factories were maintained at all points abroad where spices were produced and any trade that was carried on outside of that of the monopolizing companies was quite inconsequential. Smuggling and piracy became rife in the East Indies and spice plants were spirited out of those islands to be introduced into territories beyond the control of the Dutch. This and the complexities of a fast-growing economic system and a changing political world brought the spice monopoly to an end and the era of free commerce began.

Strabo said that even a camel driver might attain some sort of wealth from trading in spices; Van Neck's spice cargo, sold on the Amsterdam exchange in 1599, brought a profit of one hundred per cent to each of the shareholders who financed his expedition. The Dutch East India Company paid a dividend of forty per cent in 1669, but today the spice trade knows no such handsome returns. In all its long history, the spice trade probably never made less profit than it does today. It is now a highly competitive field for all concerned from grower to retailer and financial returns from the spice industry are no higher today than those of the food industry generally.

We have seen that the Dutch East Indies produce the world's greatest supply of pepper and that the other spices come from widely separated parts of the world, including the East and West Indies, India, Africa, Europe, China, and other distant places. Before World War II, the spice trade was carried on in all parts of the world without hindrance, but the global nature of the industry was its nemesis when war came to the world in 1939. The East Indies and Malay States fell into the hands of the Japanese and the pepper and other spices of these parts were cut off.

The Second World War had a devastating effect upon the spice trade of the Far East. Prior to the war Indonesia supplied more than 80% of the world's pepper requirements. Cultivation was seriously affected by the Japanese occupation. The Japanese instructed the growers to replace pepper with cotton and ricinus (castor-oil plant). The growers evaded the instruction by clearing only those pepper gardens which were easily accessible from roads and highways. Gardens in less accessible localities were not molested, but since there was no market for the pepper they were neglected. When the Japanese surrendered the growers replanted the land with rice and pepper. Later replanting of pepper was stimulated by the high prices paid for the product. It was estimated that the pepper acreage of the Lampong District lost through destruction and neglect amounted to about 75% of the prewar area. Before the war Banka had about 12,000,000 pepper vines. In May 1947 there were approximately 150,000.*

According to the Central Bureau of Statistics, Indonesia, in the year 1936 that country exported 136,124,404 pounds of black pepper and 39,449,511 pounds of white; in 1941 the exports were 71,118,911 pounds of black pepper and 22,672,336 of white; then they fell drastically to 6,009,800 pounds of black pepper and 82,000 pounds of white in 1949.

Greatly reduced shipping space and enemy attacks seriously affected the import of cassia, cinnamon, cloves, ginger, mace, nutmeg, and other spices from India, Ceylon, Zanzibar, Africa, and the West Indies. For pepper, the Allied powers had to depend on warehouse stocks and the comparatively small output of southern India. War-torn Europe was practically wiped out as a source of supply for paprika, caraway, anise, sage, and other spices. Some neutral countries maintained a trickle of supply of some of these spice products, but both quantity and quality were lacking. Spice production in North and South America was adversely affected by war priorities for labor material and transportation, further handicapping the trade. As warehouse stocks dwindled, the situation became critical and a strict rationing of essential spices became necessary. All told, the situation was most dismal for all and for those depending on spices for a living, the situation was serious.

A notable result of all this was the impetus given the manufacture of artificial and imitation spices. Special legislation in the United States of America and in Canada authorized the manufacture and sale of imitation pepper, cinnamon, cloves, nutmeg, and other spices, which became commonplace on the shelves of spice dealers. Consumers did not like the situation, particularly those industrial users whose food products had depended for years on spice formulae which now had to be changed, but there was no choice in the matter.

Such are the effects of war on the spice industry. War, particularly in those eastern tropical or sub-tropical parts where the spice plants grow and have been cultivated for centuries past, must inevitably have an adverse effect on the trade. As far as this hemisphere is concerned the answer to this is to do what France and England did in the 18th century when they introduced the spice plants of the East Indies into other parts of the world to defeat the Dutch monopolistic policy.

Today, the West Indies contribute large quantities of allspice, ginger, nutmeg, and a small amount of turmeric to the spice trade; Mexico yields capsicum chillies, anise, cumin, sesame, origanum, and Mexican allspice;

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* Foreign Trade Information Service, Department of Economic Affairs, Indonesia.

Guatemala exports cardamom, allspice, sesame seed and laurel leaves; Salvador exports sesame seed and small quantities of cardamom and allspice; Nicaragua exports sesame seed; Brazil* now cultivates the pepper plant and exports black and white pepper; Ecuador exports a small quantity of black pepper; Honduras a fair amount of allspice; and Trinidad produces a small quantity of netmeg. Production of spices in these countries could be increased. Some years ago the United Fruit Company planted an experimental acre of nutmegs in Almirante, Panama, and a few trees at Lancetilla, Honduras, which have produced nutmegs of satisfactory color, odor, and flavor, and which were found to be quite high in both volatile and non-volatile oils. Perhaps cinnamon cassia and cloves could be successfully introduced into the warm climate of Central America.

Growers in the United States are making an excellent contribution to the trade and sending to market a number of spices including paprika, red pepper, chillies, chervil, dill, garlic, marjoram, mint, mustard seed, onion, parsley, tarragon, and thyme.

The spice industry in the United States is of major importance and is dependent to a large extent on the products of other lands as will be readily realized when we consider that over 237,000,000 pounds of spices, aromatic seeds and herbs were imported in the year 1967. The ravages of war can be very damaging to the American spice trade. Imitation spices helped us out during World War II, but they cannot subsitute for the full flavor of Nature's aromatic leaves, barks, flower buds, fruits, seeds, and rhizomes. Since the dawn of time man has derived the greatest pleasure from the spices, "the veritable products of the gods," and there is every reason why he should continue to do so in war and peace.

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* See Pepper, Part 2 of this volume.

Part 2

THE SPICES DESCRIBED

INTRODUCTION

IN the course of growth, plants absorb external substances and transform them into cellulose, starch, sugars, gums, proteins, tannins, fats, essential oils, resins, and other products. Some of these are essential to plant development and function, some are necessary for energy and food reserves, and some are not fully understood by-products of the complex physiological processes of plant life. Of interest to us in the latter group are the essential oils.

Essential oils are odoriferous compounds, and it has been suggested that where the odors are irritating or disagreeable they might afford protection to the plant against attack from animals and parasites, that where they are pleasant they may serve to attract animals which aid seed dispersal, that they may effect some measure of temperature control, that they may function as reserve food, that they may have healing virtues, or that they may be no more than waste products. Whatever their real purpose in nature they have certainly served to bring a number of aromatic plants to the attention of man from the earliest ages, parts of which he found he could utilize to flavor his food, and which he has called "spices."

The plant parts which consitute the spices are rhizomes or underground stems, from which we get ginger and turmeric; bulbs, from which we get garlic and onion; barks, from which we get cinnamon and cassia; leaves, from which we get herbs such as marjoram, rosemary and thyme; buds, from which we get cassia buds and cloves; flowers, from which we get saffron and the flowering tops of herbs; fruits, from which we get allspice, pepper, paprika, cardamom, coriander and a number of other spices; and seeds, from which we get nutmeg, sesame, mustard and poppy.

These plant parts contain essential oil and other chemical substances which give them fragrant, aromatic, pungent, acrid, bitter, or other properties of aroma and taste. In some the aroma may be relatively mild but the taste biting and burning as, for example, capsicum chillies and, in a lesser degree, black pepper. In others there is a pronounced aromatic odor and taste as in allspice, cloves, and cinnamon.

Essential oils contain a variety of organic chemicals, all contributing to the fullness of their flavor, but often one or two playing a leading part as, for example, *eugenol* in cloves and allspice, *cinnamic aldehyde* in cinnamon and cassia, *carvone* and *limonene* in caraway seed.

The essential oil is concentrated in special cells of the various plant parts. These may be separate cells, or a series of cells forming ducts or canals within the tissue, or they may be glands in the epidermis.

Producers are careful to avoid loss of essential oil in the drying and preparation of spices for market, particularly where the essential oil is contained in cells near or in the epidermis as, for example, in the leaf spices, usually classified as herbs. The highest concentration of essential oil is believed to be reached at the time the plants come into bloom and it is at this time that harvesting is usually carried on. Petals and other flower parts also contain essential oil, and in those herbs where flowering tops are present their value is not less than that of the leaves.

Spices are grown in many parts of the world and according to climatic conditions may be dried outdoors or indoors. Either way, drying is a matter for care. Over exposure to air and sunlight can cause a loss of essential oil, as can too much artificial heat and too rapid drying. When artificial heat is employed it is carefully controlled and effectively circulated, beginning with a moderate degree of heat and gradually increasing the temperature to the permissable maximum.

Some growers abroad export their products through their own organizations or through exporting houses that are thoroughly acquainted with the numerous spice importers operating in all spice-buying countries. The modern distribution of spices is carried on in most countries by spice millers, wholesalers, and retailers. Imported spices are obtained directly from overseas sources or through brokers and importing houses specializing in spices. Small retailers do not usually import, but buy their spices from manufacturers and wholesalers; large retail organizations invariably have their own spice importing and milling departments. They do, of course, give the public a full choice of the products of other spice merchants and manufacturers as well as their own.

When the whole spices reach the spice merchant some will be set aside for sale as such, and some will be reduced to powder to meet the needs of cunsumers. Some of the spices to be ground will first require to be brought to a suitable size for milling—barks, for example. To accomplish this the miller will use a knife cutter or cracking machine. According to the amount of fiber or oil content (ginger, for example, is high in fiber, nutmeg high in fixed oil), he will then process the spice through a suitable grinding machine or machines, and with the aid of another machine he will sift the product through a screen to bring it to the desired degree of fineness. There are a number of machines in use for grinding spices including hammer mills, roller mills, attrition mills, limited mills, and pulverizers. Some millers do not use separate machines for grinding and sifting but employ a combined grinding and sifting machine, of which there are various kinds.

Ground spices are sold in bulk quantities to industrial users; those sold by retailers appear on their shelves in small, household-size sifter containers, such as those the shopper at the beginning of this volume was gazing at in the spice section of a modern department-store groceteria.

Essential oils are volatile—that is, they vaporize at room temperature. Now, remembering that the essential oils are concentrated in special cells of the plant it will be obvious that grinding creates a large area of exposure and, therefore, ground spices must be kept tightly capped in their containers when not in use or the quality and flavor will soon be dissipated. Whole spices are naturally better fortified against loss of their volatile constituents but nevertheless suffer deterioration over a period of time through exposure to air, and they too should be kept in closed containers.

For those readers that want to know something about the various members of the spice family the following information is given. In the description of the various plants botanical terms have been avoided as much as possible.

ALLSPICE

Allspice is the dried fruit of *Pimenta officinalis* Lindl., an evergreen tree native to the West Indies and the neighboring coast of continental America. It belongs to the *Myrtaceae*, or Myrtle family.

The allspice tree is erect with numerous branches and dense foliage, and reaches a height of twenty-five to thirty feet. The leaves are oval-oblong to elliptical in shape, from four to six inches long, entire, shiny, and deep green. The flowers are small, white to greenish-white in color, and borne on racemose cymes.

Allspice is cultivated in the West Indies, mostly on the island of Jamaica, and in Guatemala, Honduras, and Mexico.

The trees begin to bear fruit in commercial quantities when they are about seven years old, and their productivity increases yearly for about another twelve years.

Since the fully ripened fruits loose much of their aromatic qualities the fruits or berries are gathered when mature, but still green. The fruit-bearing

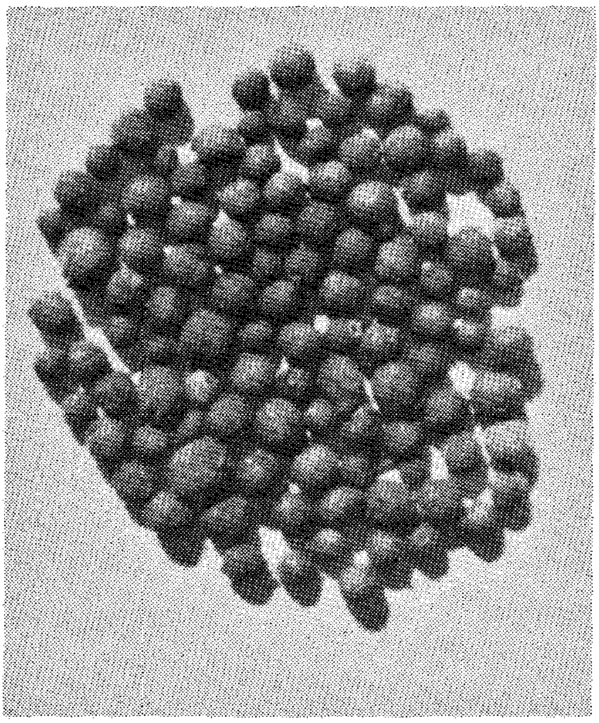

Fig. 1. Jamaica Allspice.

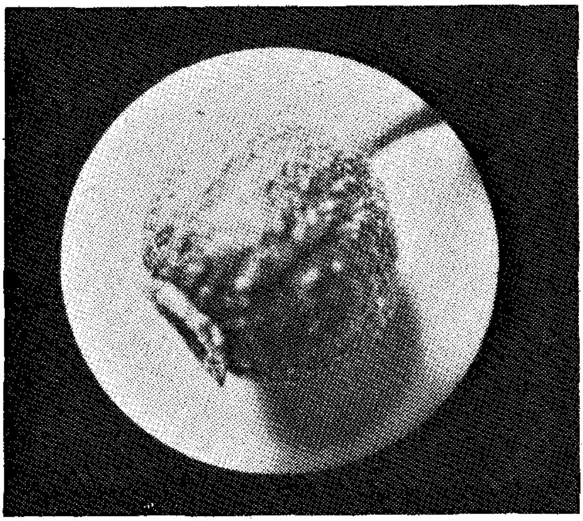

Fig. 2. Jamaica Allspice× 7½.

twigs are broken off the trees and the berries are removed by hand or flails. Undesirable berries are sorted out and discarded and the remainder spread out to dry in the sun. During the drying period, which takes from six to ten days, the berries turn to a dull reddish-brown, and their aroma becomes more pronounced. After drying, the berries are packed for export, those from Jamaica in jute bags. Nearly two-thirds of the allspice imported into the United States of America comes from Jamaica.

The dried allspice berry is nearly globular in shape, with the remains of the style and calyx at the apex, and on some berries a short length of stalk at the base. The berries vary in size from about 1/8 to 5/16 inch in diameter. Minute protuberances caused by numerous essential oil cells just under the epicarp give the berries a rough surface. Each berry contains two dark-brown seeds.

Allspice has a fragrant aroma reminiscent of cloves, and a pronounced aromatic, pungent taste. The fruit is called "Allspice" because its flavor is said to resemble a combination of cinnamon, nutmeg, and cloves.

This popular spice is used both whole and ground. It is used in the kitchen for flavoring meats, gravies, sauces, relishes, pickles, preserves, mincemeat, puddings, cakes, beverages, etc. It is employed by food manufacturers in the preparation of fancy meats, meat sauces, catsup, pickles, etc. Whole allspice is an ingredient of Whole Mixed Pickling Spice, and ground allspice is a constituent of a number of spice mixtures including curry powder, mincemeat spice, pastry spice, etc.

ANISE

Anise is the dried fruit of *Pimpinella anisum* L., an annual herbaceous plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley family). It is native to Egypt and neighboring coastlands, and is cultivated in many parts of the world including Spain, France, Italy, Turkey, Lebanon, Russia, Bulgaria, Cyprus, Malagasy Republic, India, China, Japan, Mexico, and Argentina. In recent times, most of the anise imported into the United States of America has come from Turkey, Spain, and Syria.

The anise plant attains a height of one to two feet, and has an erect, branching stem. The leaves vary in shape from broadly triangular, cleft and irregularly toothed at the base of the plant, to narrow segments in the upper parts. The flowers are small, white, and borne in compound terminal umbels. The fruit consists of two united carpels, each carpel containing a single seed. The plants are harvested when the fruits begin to ripen. They are piled into stacks and left in the field until ripening of the fruit is complete. The fruits are then separated by threshing.

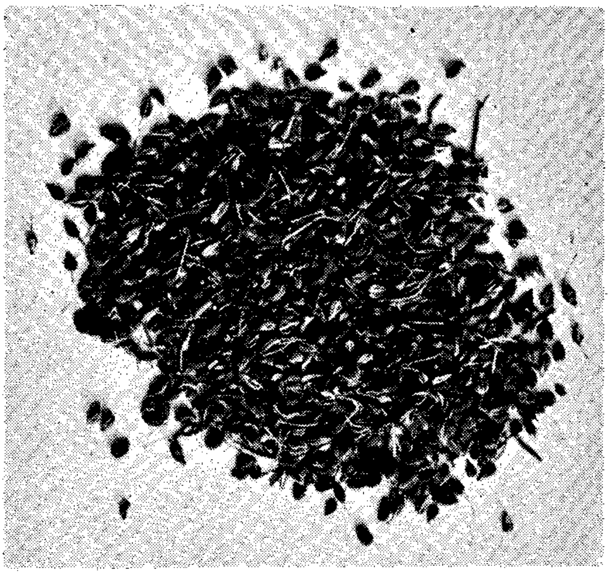

Fig. 3. Aniseed.

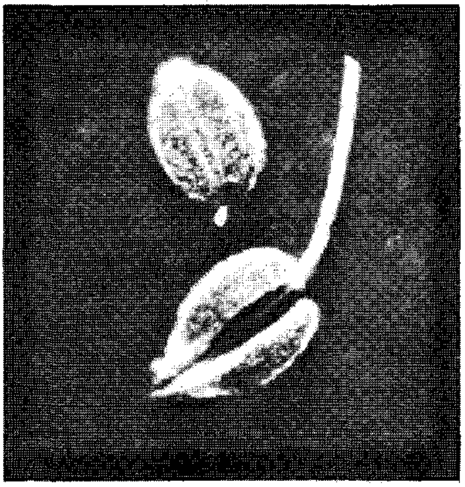

Fig. 4. Aniseed × 7½.

Aniseed

Dried anise fruit, commonly called aniseed, is small—about 3/32 to 3/16 inch in length. The whole fruit is ovoid in shape, usually with a short length of stalk attached, has numerous short hairs, and is grayish-green to grayish-brown in color. It has been described as looking like a tiny mouse. A sample of aniseed consists of whole fruits and separate carpels.

Aniseed has a characteristic, pleasing, aromatic aroma and taste. It is used to flavor rolls, cakes, cookies, biscuits, licorice, and confections.

CAPSICUM SPICES

Capsicum spices are prepared from the dried fruits of plants of the genus *Capsicum*, belonging to the *Solanaceae* or Potato family. The genus is native to tropical America. Capsicum plants are cultivated in nearly all tropical and sub-tropical countries and in many regions of the temperate zones.

Capsicum plants are herbaceous or semiwoody annuals or perennials, reaching from about eighteen inches to four feet in height. The leaves are ovate, tapering to a sharp point, entire, up to six inches long, darker green on the upper surface, paler on the lower. The flowers are small, white, and borne solitary or in clusters of two or three in the axils of the leaves. The fruits are of diverse shape and size depending upon the variety of capsicum cultivated.

From capsicum fruits we get paprika, cayenne pepper, red pepper, chilli powder, and chillies.

Paprika

Paprika is manufactured from the large fruits of *C. annum*, and may be sweet, semisweet, mildly pungent, or pungent. It ranges in color from a bright rich red to a brick-red depending upon the selection, quality, and preparation of the pods for grinding. The better the quality, the better the color.

Paprika is produced in Spain, Portugal, Hungary, Yugoslavia, Bulgaria, Turkey, Mexico, Chile, Canada, United States of America, and other parts of the world. About half of the total quantity of paprika imported by the United States has come from Spain in recent times.

Spanish paprika is the finely ground product of mature, sound, clean fruits, deprived of peduncles and calices, of *Capsicum annum* L.

There are three classes or types of Spanish paprika—namely, "Dolce" or Sweet, "Agridulce" or Semisweet, and "Picante" or Pungent. The last mentioned is not exported to the United States of America. Three qualities of each type are manufactured: Extra, Select, and Common. The *Extra* quality is manufactured, exclusively, from the pericarp (the fleshy wall or

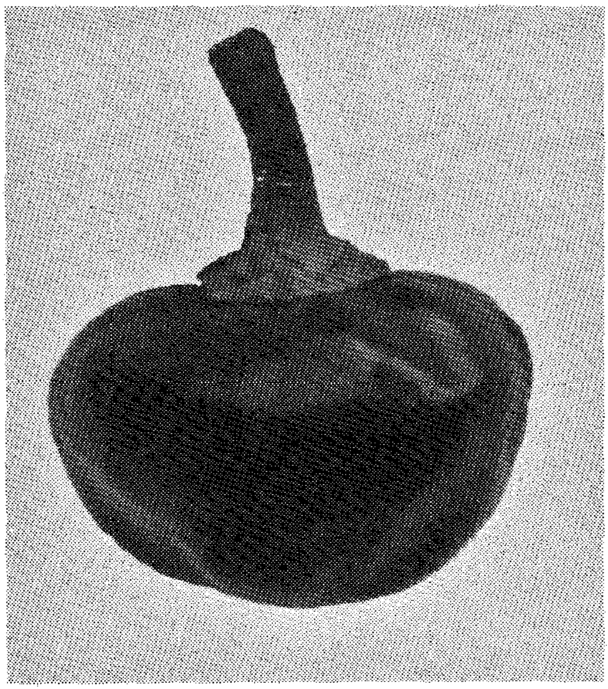

Fig. 5. Spanish Paprika Pod (Variety *Ramillette*). Courtesy of *The Ministry of Agriculture, Murcia, Spain.*

outer part of the fruit) of first quality fruits with no placenta tissue, seeds, calices or peduncles permitted in the product. The *Select* quality is prepared from the pericarp and seeds, the latter limited to 10%. The *Common* quality may contain up to 30% seeds. The color of Extra quality Spanish paprika is a rich red, that of Select a less intense red, of Common a brick-red.

The Sweet paprikas are the products of four varieties of capsicum peppers known in Spain as *Ramillete*, *Tres Cascos*, *Bola*, and *Albar*. The plants are cultivated in the southeast of Spain and in the regions of Andalucia and Extramadura.

Portugal exports two types of sweet paprika—namely, "Doce-Extra" and "Doce-Superior" (formerly "Chouriciero" and "Doce-Extra").

Doce-Extra paprika is prepared from the pericarp of first quality capsicum peppers deprived of peduncles, calices and seeds. *Doce-Superior* is similarly prepared but with the addition of a permissible quantity of the seeds. The seeds are macerated and washed in water to rid them of part of the pungent substance *capsaicin*; they are then dried and ground. The color of Doce-Extra paprika is a rich red, that of Doce-Superior a less intense red.

Hungarian producers claim an unsurpassed excellence for their paprika. They produce five types of paprika, namely, "First Quality" or "Noble Sweet," "Semisweet," "Rose," "Pungent," and "Mercantile."

Noble Sweet paprika has a rich red color, and a sweetish, slightly pungent flavor. It is prepared from the pericarp of capsicum peppers of first quality, free from peduncles and calices, but including the seeds, which have been treated as above.

Semisweet paprika is similarly prepared but may, in addition, include placenta tissue. Its color is similar to that of Noble Sweet paprika.

Rose paprika utilizes all of the fruit except the peduncles and calices. It is a pungent paprika, and its color is not quite as rich a red as the former types.

Pungent paprika is actually a second quality Rose type paprika. It is prepared similarly to Rose paprika but from capsicum peppers of a lower quality. Its color is brick-red.

Mercantile paprika is a third quality product prepared from portions of fruits remaining from the manufacture of the better quality paprikas. It may contain parts of calices and, more rarely, peduncles. Its color is brownish-red or brownish-yellow.

Capsicum plants cultivated for the production of paprika are propagated from seed sown in nursery beds. The seedlings must be fully protected against low temperatures and cold winds. They are transplanted to the field as early in the year as the climate permits. Harvesting of the peppers commences in the first part of September and continues as the fruits mature but not beyond the end of October. Plants bearing immature fruits at the end of October are pulled from the ground and hung up for the fruits to mature. The mature fruits of such plants, however, are generally considered to be of inferior quality.

In Spain and Portugal the harvested fruits, as a rule, are piled if possible on a hill side facing south, for a period of twenty-four hours. If they are to be sun dried, the fruits are then cut open or sectioned and spread on drying floors or on mats laid over well drained ground, and fully exposed to the sun.

When dried artificially, the fruits are sectioned and spread on trays in drying houses and exposed to a temperature of 60°C (140°F). The drying time varies depending upon whether or not the fruits have been partially dried in the sun; in the first case about eight days will be required to complete the drying process, and in the second from twelve to fifteen days. (United States producers have an efficient method of drying paprika pods in from 8 to 10 hours.)

Whether drying is natural or artificial, methods vary somewhat in the different countries and districts of production.

After drying, the fruits are sorted into categories, being selected for the qualities required in the different types and grades of paprika to be manufactured. Peduncles and calices are removed and the peppers otherwise prepared for milling.

Grinding is an exact process involving the use of roller mills and sifting apparatus. Usually a series of mills with iron rollers and one mill with emery rollers are employed. Several grindings and siftings are required to bring the paprika to the required fineness. The peppers passing through the first mill are sifted through a fine mesh screen and that portion of the product not fine enough to pass through the screen is ground again through the next mill, and so on, until the whole batch is of the required degree of fineness and smoothness. In some factories as many as nine mills may be used to complete the grinding process. In others, the peppers may pass through a series of four mills with iron rollers and one mill with emery rollers, the product being screened after each grinding. Finally, the paprika that has passed through the screen after each grinding is then conveyed to a mechanical batcher to be thoroughly mixed and homogenized. It is then packed and labelled for market.

Paprika has numerous culinary uses. It is employed for flavoring and garnishing meat and fish dishes, poached and devilled eggs, salads, canapes, etc. It is used by the food manufacturing industry in the preparation of fancy meats, catsup, sauces, and other prepared foods.

Paprika contains appreciable amounts of Provitamin A and Vitamins C, P, and J.*

Cayenne Pepper

Cayenne pepper is ascribed by United States government standards to the dried, ripe fruits of *C. frutescens* L., *C. boccatum* L., or some other small-fruited species of capsicum.

The name of this pepper is said to be derived from the river Cayenne in French Guiana, South America.

The dried fruits employed in the manufacture of cayenne pepper are the small chillies grown in Africa, Japan, Mexico, and the United States of America. The chillies are mechanically ground and then sifted through a fine screen to produce the pepper.

Red Pepper

Red Pepper is the ground product derived from the above chillies and also from the large, long peppers of the Cayenne group such as the Long Red Cayenne.

Cayenne and Red peppers, used with discretion, add flavor to meat, fish, and egg dishes, sauces, etc.

Chilli Powder

Chilli powder is prepared from mild or pungent capsicums including the large Mexican chilli pods known as Chile Ancho, with the addition of other spices such as cumin, oregano, garlic powder, and onion powder.

Chilli powder is used in the preparation of chili con carne, fish and oyster cocktail sauces, and with eggs, omelets, stews, etc.

Chillies

The small chillies, known as Nigerian, Mombassa, Congo, Zanzibar, or African chillies; Japanese hontaka, Mexican chiltepin, Louisana sport, and Tabasco are all very pungent capsicum fruits. They are used in the manufacture of Cayenne pepper, and are employed in the preparation of various kinds of pickles. They are an ingredient of whole mixed pickling spice.

The small African peppers should be handled with care. They are particularly fiery, acrid, and biting. After handling these chillies the fingers

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* Instituto Nacional de Investigaciones Agronómicas Ministerio De Agricultura, Murcia, Spain. UNE 34029. ("Vitamin J, a postulated antipneumonia principle which was also designated C_2," *Vitamins and Coenzymes*, Arthur Wagner and Karl Folkers, Copenhagen, 1964. John Wiley and Sons Inc., N. Y.)

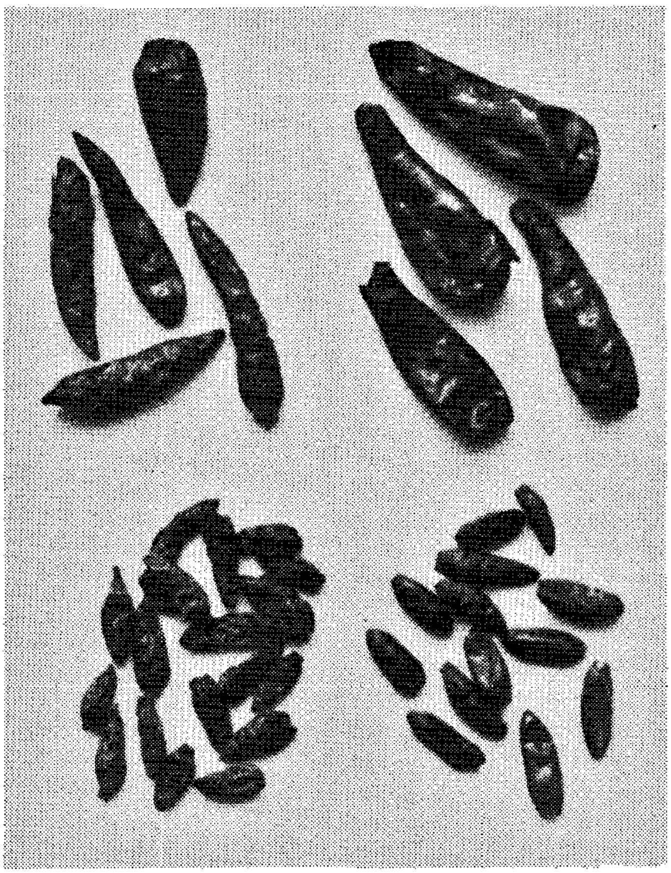

Fig. 6. Chillies. *Top left:* African Nigerian. *Top right:* Japanese Honka. *Bottom left:* African Mombassa. *Bottom right:* Mexican Chiltepin.

should not be brought in touch with the eyes, and the chillies should not be tested by tasting.

CARAWAY

Caraway is the dried fruit of *Carum carvi* L., a biennial herbaceous plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley family). The caraway plant is native to Europe and western Asia. It is cultivated in many parts of the world including Holland, Poland, Syria, Russia, Bulgaria, Rumania, Morocco, United Kingdom, Canada, and the United States of America. Most of the caraway imported into the United States

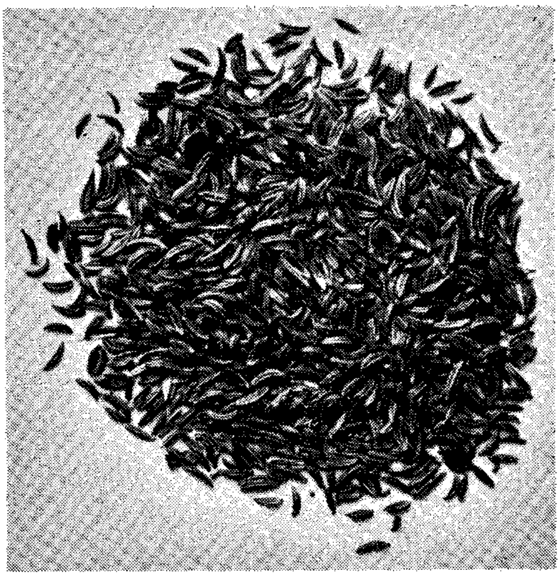

Fig. 7. Caraway Seed.

comes from Holland. Dutch caraway enjoys a reputation for superior quality. The heavy clay in North Holland and Groningen and the humid climate prevailing in those regions provide excellent conditions for caraway cultivation. The essential oil content of Dutch caraway is high, and it is said that the sea climate favors the formation of carvone, its principal chemical constituent, primarily responsible for the caraway flavor.

The caraway plant reaches a height of about two feet. It has compound leaves cut into feather-like, narrow segments, and small, white flowers borne

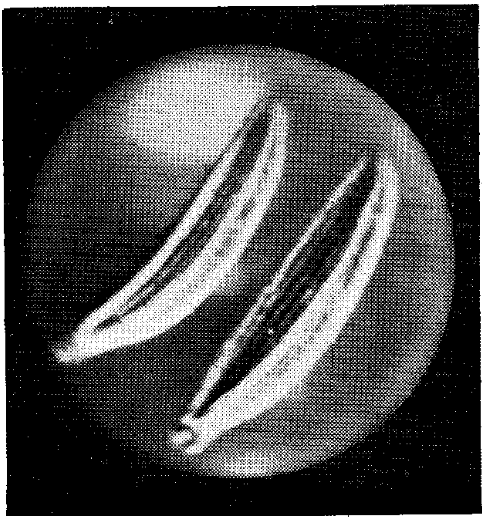

Fig. 8. Caraway Seed × 7½.

in terminal compound umbels. The fruit consists of two united carpels, each carpel containing a single seed. In Holland, harvesting of the plants begins in the first days of July of the second year just as the tops are brown but the stems still green. The plants are mowed in the morning or evening to avoid loss of seed by wind. The plants are stacked in the field to air dry and then threshed.

Caraway Seed

The dried whole fruit of caraway, commonly called caraway seed, separates easily into single carpels, 5/32 to 1/4 inch long, curved, tapering toward each end, and light to dark brown in color. A sample of caraway seeds consists almost entirely of separate carpels. Caraway seed has a characteristic, agreeable aroma, and an aromatic, warm, slightly sharp taste.

Caraway seed is available whole or ground. It is used to flavor confections, bread, biscuits, cakes, cheese, and cheese spreads.

CARDAMOM

Cardamom is the dried fruit of *Elettaria cardamomum* Maton., a perennial herbaceous plant belonging to the *Zingiberaceae*, or Ginger family, and native to India.

Cardamom is cultivated in India, Ceylon, Guatemala, Costa Rica, and Salvador.

Although cardamom can be raised from seed, propagation is usually by division of carefully selected rhizomes, or "bulbs" as they are called, eighteen months to two years old, and with at least two growing stems. An alternative method, not uncommon, is to take up mature plants and carefully divide them making sure that each has its proper proportion of rhizomes. The plants are spaced eight feet apart.

After planting out, very little cultivation is required. For the first two years periodic weeding is necessary, but when the plants are fully formed the weeds have little space or opportunity to flourish and only occasional attention is necessary. The plants are periodically cleaned of dried leaves, damaged and decaying stems.

The stems of the cardamom plant rise six to twelve feet and bear long, lance-shaped leaves terminating in an elongated point. The flowers, which

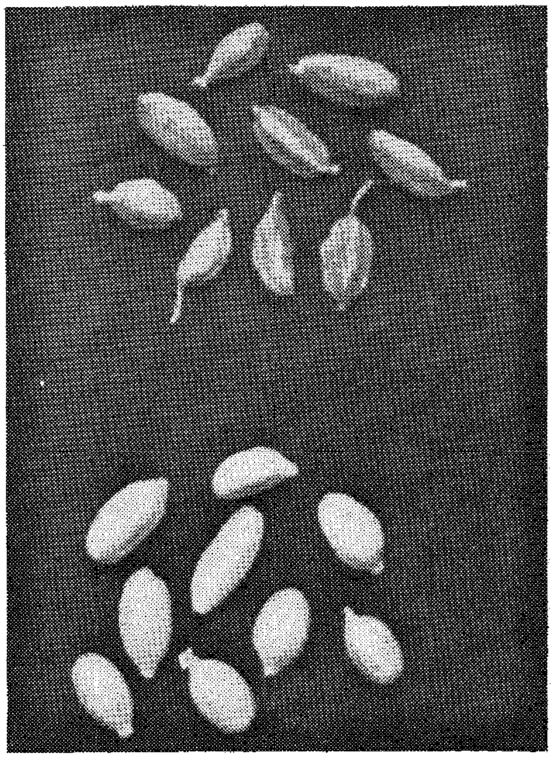

Fig. 9. Cardamom Seed. *Top:* Green Cardamoms. *Bottom:* Bleached Bold Cardamoms.

consist of a pale green corolla tube and a white petal-like lip with pink or purplish veins, are borne on separate stems, more properly racemes, which may stand erect or spread along the surface of the ground according to variety. The fruit consists of a three-celled capsule, each cell containing a number of seeds.

At lower elevations cardamom plants bear fruit in two years, at higher elevations a small crop may be expected in the third year. From about the fifth year full crops may be expected for some years. At lower elevations full production continues for a further six years or so, and then declines. At higher elevations good crops may be expected for a further ten years or so.

Cardamom plants may blossom all the year round but there is a definite flowering season. In India and Ceylon this is from April to July. Harvesting of fruits may begin in August and continue until December. At lower elevations the fruit reaches maturity in three to four months, at higher elevations in about five months. Since the fruits are borne in succession they must be collected carefully to avoid damage to the raceme bearing the blossoms, and this is accomplished by cutting off individual fruits with a pair of scissors.

Cardamom fruits turn pale green on ripening and are harvested before full maturity. Fruits allowed to remain on the racemes turn a deep yellow in color and fall naturally from the plant. Such fruits are unsuitable for curing as they split during drying.

In India and Ceylon there are two methods of preparing cardamoms for market, namely, "Sulphur bleaching" and "Green curing." Sulphur bleaching, briefly, involves sulphur fumigation with alternate periods of soaking and drying. It is carried out in four stages with a final drying in the sun, the whole process taking from ten to twelve days to complete.

There are two methods of green curing: (1) by drying the cardamons in a heated chamber, and (2) by drying over an open charcoal fire in a closed chamber. In the former method the cardamoms are spread on trays and placed in racks arranged in tiers eight to nine inches apart. Hot air from a furnace in an adjoining room is carried along heating flues which lie a few inches above the floor of the curing chamber. In the latter method, the cardamoms are spread on trays with a wire mesh bottom and placed over a slow burning charcoal fire for about twelve hours. They are then transferred to trays with a jute hessian bottom and placed on a higher rack for a further twenty-four hours to complete the curing and drying.

Before marketing, the stalks and calyces are removed from the dried cardamoms. This is accomplished by clipping with scissors or by rubbing the cardamoms over a coarse surface of jute hessian or wire mesh. They are then sorted by hand picking. Damaged, shrivelled and very small capsules are removed and used for extraction of seed. The cardamoms are then graded into "longs," "mediums," and "shorts."

Bleached cardamoms are creamy-white in color; green cardamoms are greenish-yellow.

Whole cardamoms possess an aromatic aroma. The seed has a pleasing aromatic aroma, and a characteristic, warm, slightly pungent, highly aromatic taste.

Cardamoms are available whole, decorticated (i.e. capsule removed), and ground. This delightful spice is used to flavor breads, buns, pastries, cakes and cookies. It is a constituent of good quality curry powder, and is an ingredient of liver sausage, pork sausage and hamburger seasonings.

CELERY

Celery is the dried fruit of *Apium graveolens* L., a biennial herbaceous plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley family). The celery plant is native to southern Europe and northern Africa. It is cultivated for its fruits in France, India, Japan, United Kingdom, and the United States of America. Most of the celery fruit imported into the United States comes from India.

The cultivated celery plant reaches a height of about eighteen inches. It has compound, coarsely toothed, segmented leaves, and very small, white flowers borne in compound umbels. The fruit consists of two united carpels, each carpel containing a single seed. The fruits are collected when fully ripe.

Celery Seed

The dried fruit, commonly called celery seed, is very small, rarely exceeding 1/16 inch in length, and grayish-brown in color. A sample of celery seed consists of whole fruits and separate carpels. Celery seed has a characteristic fresh celery aroma and taste, the latter warm and slightly bitter.

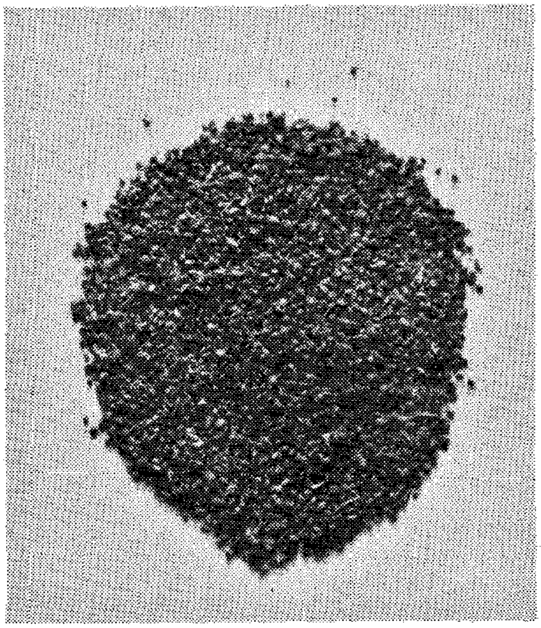

Fig. 10. Celery Seed.

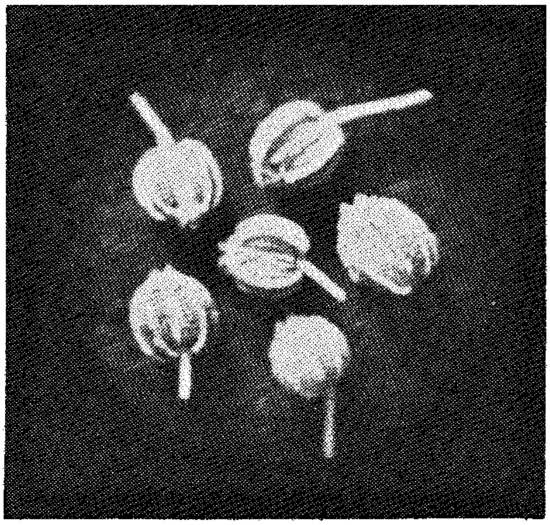

Fig. 11. Celery Seed × 7½.

Celery seed is available whole or ground. It is used as an effective and convenient substitute for fresh celery to flavor soups, sauces, salads, pickles, spreads, tomato juice, and other foods.

Celery Salt

The ground seed mixed with free-running table salt is sold as celery salt, an excellent compound to flavor and season fish, egg dishes, salads, salad dressings, bouillon, tomato and other vegetable juices.

Celery Pepper

Celery pepper, a mixture of ground celery seed and ground black pepper, is also available.

CINNAMON

Ceylon Cinnamon

Ceylon cinnamon is the dried inner bark of *Cinnamomum zeylanicum* Nees., Family *Lauraceae* (Laurel family), an evergreen tree native to Ceylon and

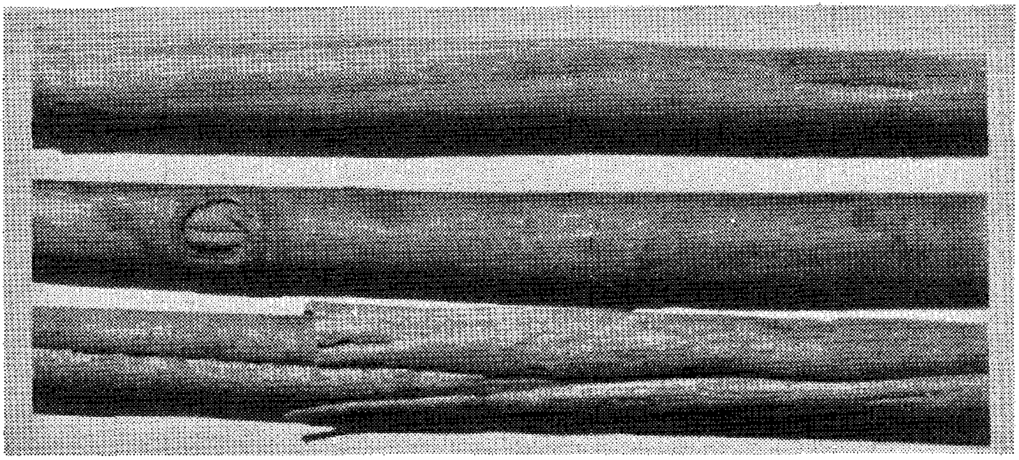

Fig. 12. Ceylon Cinnamon.

the neighboring Malabar coast of India.

The cinnamon tree is commonly found in the wet forests of Ceylon up to an elevation of 5,000 feet. It has numerous branches and reaches a height of thirty to fifty feet. The leaves are from four to seven inches long, leathery, bright green, and with three prominent ribs. The flowers are small, and yellowish in color.

Under cultivation, cinnamon is grown as a bush and by cutting back at regular periods is kept to a height of six to eight feet. The plant can be propagated from cuttings but it is generally raised from seed sown in nurseries, usually in July or August. The seedlings are ready for transplanting in the field in the following April or May when the monsoon rains begin.

In two or three years the plants will have attained a height of five or six feet and at this time two or three shoots may be taken from each plant for peeling. However, cutting of the shoots is best delayed until the fourth year. Two crops are taken annually, usually in May and November depending upon the rains. The bark is more easily separated from the wood following the first rains of the season.

After cutting, the shoots are bundled and taken to sheds for peeling. The shoots are first trimmed of twigs and leaves, then two longitudinal slits are made in the bark, which is gradually loosened with the knife and removed. The sections of bark are then carefully put one into the other, the outer side of one piece against the inner side of another. These are then collected and firmly bound together in bundles and set aside for twenty-four hours to "ferment." Following this process each section of bark is placed on a cylindrical piece of wood about two feet long, one end of which is supported by a low tripod of sticks, the other resting on the ground. The peeler, sitting on the ground opposite the tripod, holds the section firmly with his foot and using a small curved knife scrapes off the outer layers of the bark.

After a few hours, the smaller sections of scraped bark are introduced into the larger and pieced together to a length of about thirty-six inches. As the bark dries it contracts and gradually acquires the form of a "pipe" or "quill." A well made quill is of uniform thickness, color, and quality; the edges are neatly joined in a straight line, and the joints of the pieces are close and neat.

The production of cinnamon in Ceylon is not so great today as it was years ago. There is not a great deal of Ceylon cinnamon imported by the United States of America but it enjoys a fair demand in other parts of the world.

Spice merchants cut the quills into short lengths and package them for the retail food trade as Ceylon cinnamon sticks. Ground Ceylon cinnamon finds favor with many food processors and bakeries. It has a pleasing, fragrant odor and a warm, sweet, aromatic taste.

Cassia Cinnamon

Cassia cinnamon is the spice prepared from the dried bark of trees of the genus *Cinnamomum*, a group of evergreens belonging to the Laurel family. The species from which the spice barks are obtained are *C. cassia* Blume, *C. loureirii* Nees, and *C. burmanni* Blume. The first produces the bark which is cultivated in China and exported as Kwangsi, Yunnan, or Honan cassia depending upon the province of its origin; the second, the bark produced in the territory formerly known as French Indochina, now the lands of Laos, Cambodia, and Vietnam, and exported through the city and port of Saigon from which it takes its name; the third, the bark produced in Indonesia.

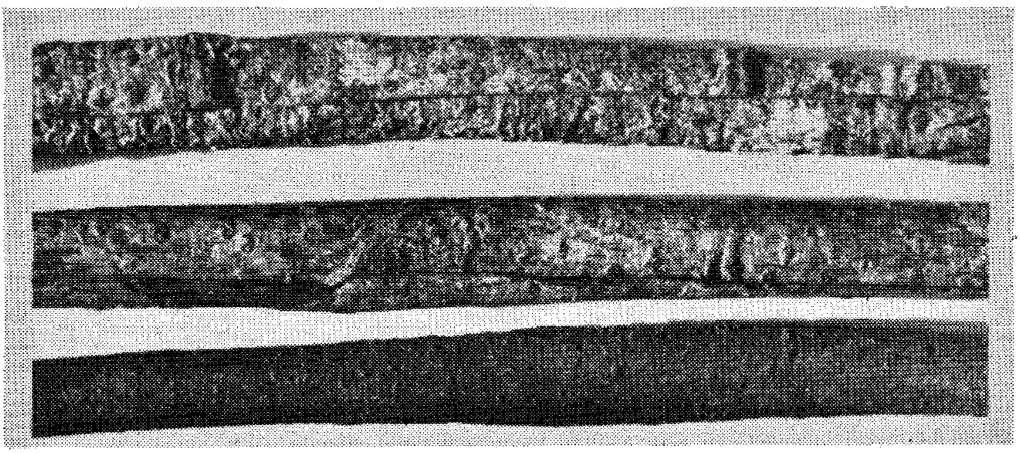

Fig. 13. Saigon Cassia.

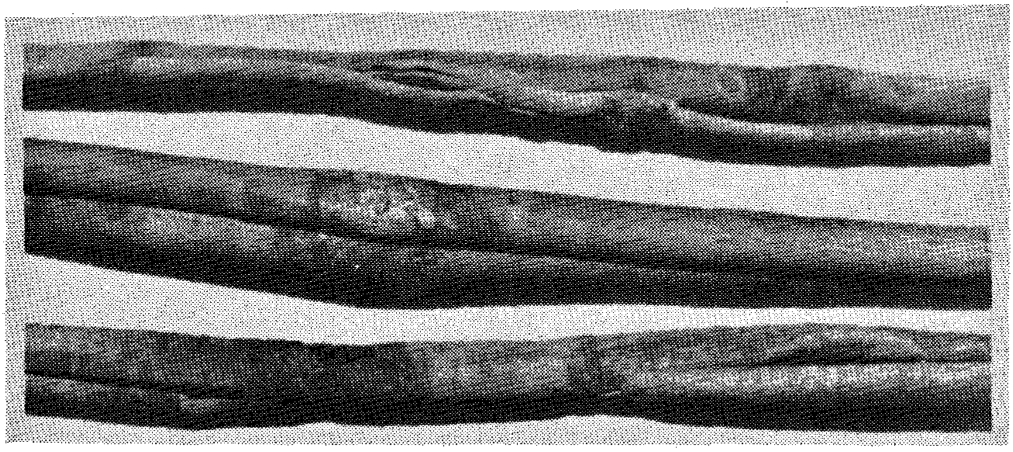

Fig. 14. Indonesia Cassia.

Until a few years ago, Indonesia cassia was known as Batavia cassia or cinnamon, taking its name from Batavia, the former capital of the Dutch East Indies. Indonesia exports three varieties of cassia namely, Korintje, Padang, and Vera.

With minor differences, the trees of the above species are of medium height with bright green, elliptically-shaped leaves from three to seven inches long, leathery in texture, and having three prominent ribs. The flowers are small, yellowish in color, and borne in panicles at the end of long peduncles or stalks.

When the trees are ready to yield they are cut down. The wood is trimmed and cut into workable lengths, gathered and conveyed to peeling sheds or areas. Two longitudinal slits are made in the bark, which is then carefully loosened with a small, curved knife and separated from the wood. Some varieties of cassia bark are scraped, others are not. As the prepared sections of bark dry they contract and curl inwards, the thin barks forming rolls or simple quills.

Cassia forms the bulk of the cinnamon imported by North American traders. Spice millers cut selected pieces of bark into short lengths for sale at retail as whole cinnamon. The greater part of the bark is processed through cracking and grinding machines, and sifted through fine mesh screens to produce ground cassia cinnamon. The various kinds of cassia bark are ground separately or blended and ground to suit the needs of the bakery and food processing industries. At retail, the product is sold as ground cinnamon without distinction as to kind.

The degree of aroma and flavor of the different kinds of cassia cinnamon bark varies, but all are agreeable, fragrant, and aromatic. Saigon cinnamon is generally acknowledged to possess the fullest and finest flavor.

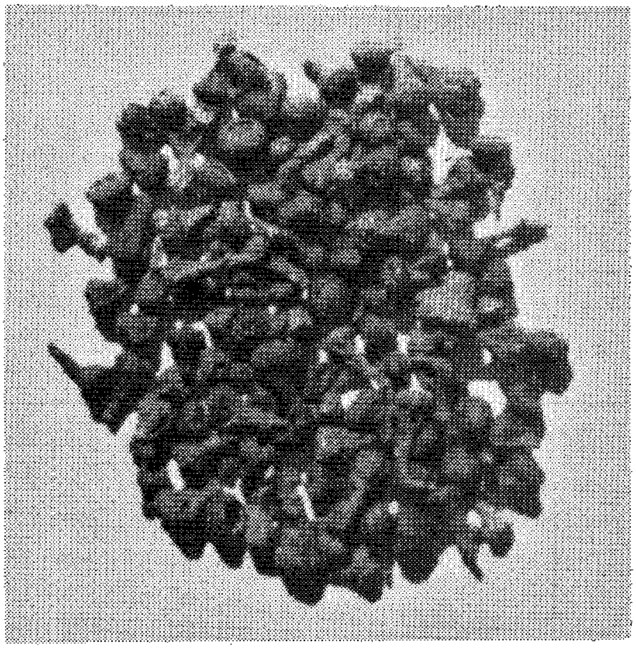

Fig. 15. Cassia Buds.

Ground cinnamon is employed to flavor breads, buns, cakes, cookies, and pies. It is used with apples, stewed fruits, and in confections. It is used commercially by bakers, confectioners, fruit canners, and other food processors. Cracked cinnamon is an igredient of whole mixed pickling spice, and the ground product is a constituent of many ground spice formulae including pastry spice and mincemeat spice.

Cassia Buds

Cassia buds are the dried, unripe fruits of *Cinnamomum cassia* Nees. The "bud" consists of a brown seed snugly secure within a cup-like, wrinkled, hard, grayish-brown calyx. The exposed part of the seed is smooth and shiny, the hidden part wrinkled.

Cassia buds possess a slight cinnamon-like aroma, and a sweet, warm, pungent taste similar to that of cassia cinnamon.

Cassia buds are used to flavor pickles and other foods.

CHERVIL

Chervil consists of the dried leaves of *Anthriscus cerefolium* Hoffm., an annual herbaceous plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley family). Chervil is native to the Black Sea and Caspian Sea regions of southern Russia, and western temperate Asia. In Europe, its cultivation is mainly in France. The North American market is supplied by growers in the United States.

The chervil plant reaches a height of about eighteen inches but under cultivation in the United States it seldom exceeds twelve inches. It has parsley-type foliage consisting of pale green, decompound, segmented leaves, and small, white flowers borne in terminal compound umbels. The seed is sown in early spring and the plants are ready for harvest in April or May. The leaves are dried indoors by circulating warm air and then reduced to tiny fragments by mechanical means.

The aroma and taste of dried chervil is reminiscent of a blend of caraway and anise.

Chervil is used to flavor soups, meat, fish, and egg dishes, dressings, and salads.

CLOVES

Cloves are the dried flower buds of *Caryophyllus aromaticus* L., an evergreen tree belonging to the *Myrtaceae*, or Myrtle family. The exact place of nativity of the clove tree is not known, but it is believed to be indigenous to the Moluccas or Spice Islands (Indonesia).

The clove tree is cultivated in the Island of Madagascar (Malagasy Republic), the Islands of Zanzibar and Pemba (Tanzania), Penang (Malaysia), Amboyna (Moluccas Archipelago, Indonesia), India, Ceylon, and other places.

The clove tree is markedly erect and reaches a height of twenty to forty feet. It has smooth, thin, gray bark, many low branches and three or more, nearly upright, main branches. The leaves are nearly elliptical in shape, dark green when mature, entire, smooth and shiny. Numerous minute oil glands give the leaves a fragrancy, especially when they are bruised or crushed. It is said that on a hot damp evening the scent of the clove tree can be detected from a considerable distance. The flowers are small, rosy, and borne in clusters of three at the end of branches. The fruit is a purple drupe about one inch long and half inch broad; it is called "mother of cloves." The clove

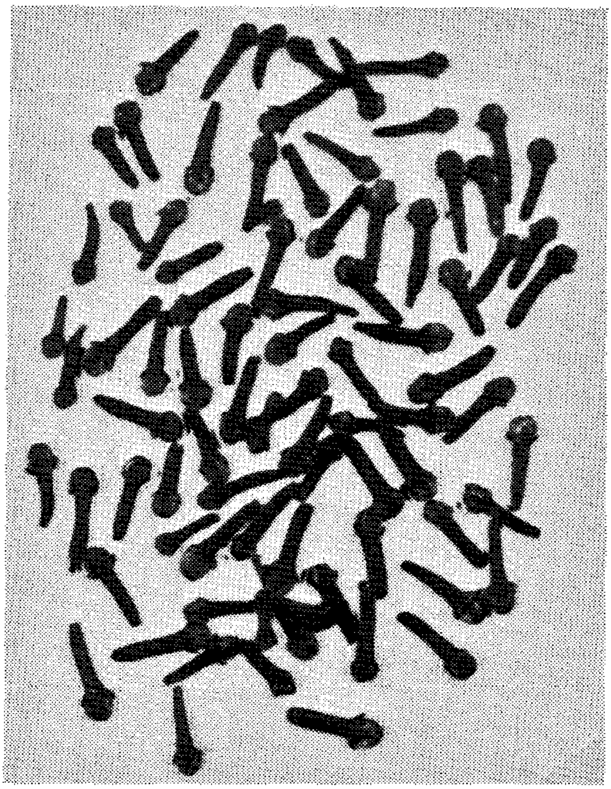

Fig. 16. Cloves.

of commerce is the unopened flower bud, and the stalks are the "clove stems" of commerce.

The trees begin to bear fruit when they are six to seven years old. When the base of the buds turns a reddish color they are ready for harvesting. Pickers climb the trees and remove the clusters of buds by hand, taking care not to break the branches, which are very brittle. The buds are later separated from the stems and spread on grass mats or cement drying floors for four or five days to dry. Drying is an important part of the preparation of the spice. Too rapid drying can cause the cloves to become shrivelled and brittle. Under bad drying and storage conditions the color becomes darker and the cloves turn musty. Finally, the epidermis becomes pale and wrinkled. Cloves of this type are known as "Khoker."

Cloves must be handled with care, especially when dry, since the "heads" or "crowns" are easily broken off. A good sample should show few headless cloves.

In size, cloves vary from 1/2 to 3/4 inch in length. They are reddish-brown in color, and complete with base and crown. Good quality cloves are large, bold, and not too wrinkled. Cloves are graded on appearance and allowances for maximum impurities. United States government standards do not permit more than five percent stems in a sample. Clove stems are largely used for distilling oil of cloves.

The word "clove" is derived from the French "clou" (clou de girofle, clove), from the Latin "clavus"—a nail—which the dried clove is said to resemble.

Cloves possess a pronounced aromatic odor and an aromatic, pungent taste.

This widely used spice is employed whole or ground and has innumerable uses in the culinary art including the studding of hams and roast pork and the flavoring of meat dishes, gravies, pickles, preserves, desserts, cakes, puddings, etc. It is an ingredient of many ground spice mixtures including curry powder, mincemeat spice, pastry spice, pumpkin pie spice, sausage seasoning, hamburger seasoning, and others.

CORIANDER

Coriander is the dried fruit of *Coriandrum sativum* L., an annual herbaceous

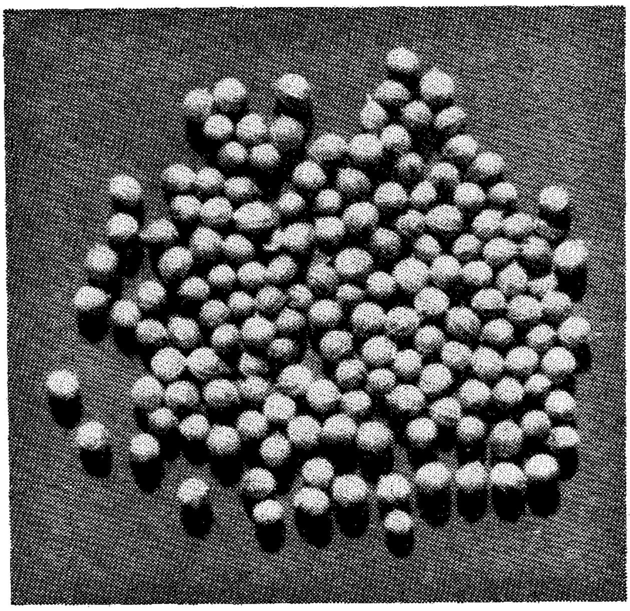

Fig. 17. Coriander Seed.

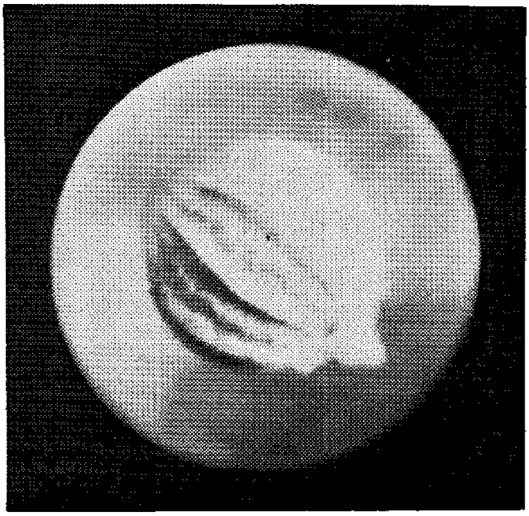

Fig. 18. Coriander Seed × 7½.

plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley family). The coriander plant is native to Mediterranean and Near East regions. It is cultivated in Morocco, Rumania, France, Spain, Italy, Holland, Yugoslavia, Russia, Asia Minor, India, Mexico, Argentina, and to some extent in England and the United States of America. In recent times, most of the coriander imported into the United States has come from Morocco, Rumania and Argentina in that order.

The coriander plant reaches a height of about two feet. It has an erect, branching stem and compound leaves. The lower leaves are broad with irregularly toothed lobes, and the upper leaves are divided into very narrow, linear segments. The flowers are small, pinkish in color, and borne in terminal compound umbels. The fruit consists of two united carpels, each carpel containing a single seed. The plants are harvested when the fruits are fully ripened, air dried, and threshed.

Coriander Seed

The dried fruit, commonly called coriander seed, consists of two united carpels, nearly globular in shape, about 1/8 to 3/16 inch in diameter, and yellowish-brown in color. The aroma of coriander seed is slightly fragrant, and the taste is agreeably aromatic.

Coriander seed is available whole or ground. It is used to flavor pastries, cookies, buns and cakes. It is employed commercially to add flavor to some processed meats. Whole coriander seed is an ingredient of whole mixed pickling spice. Ground coriander seed is a constituent of curry powder, and of seasonings for pork sausage, bologna, and frankfurters.

CUMIN

Cumin is the dried fruit of *Cuminum cyminum* L., an annual herbaceous plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley family). The cumin plant is native to Egypt and the Mediterranean region. It is cultivated in Iran, Morocco, Lebanon, Syria, Turkey, Egypt, Sicily,

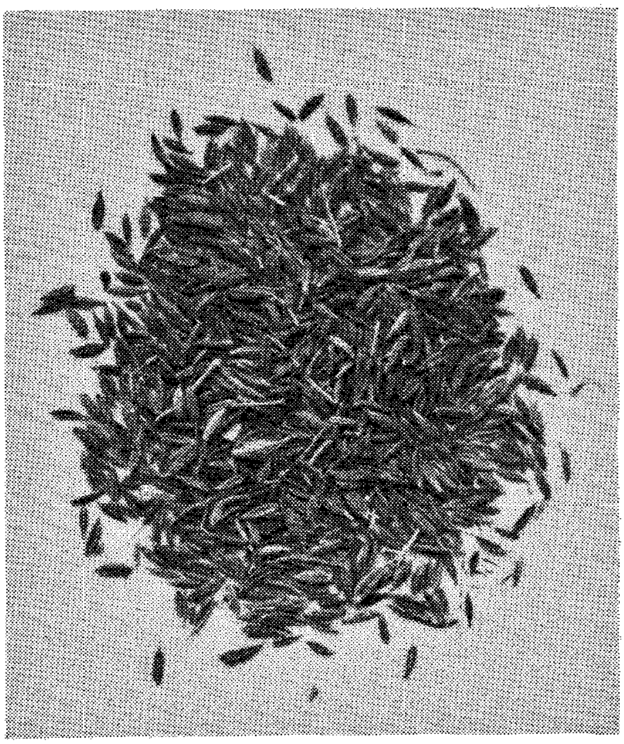

Fig. 19. Cumin Seed.

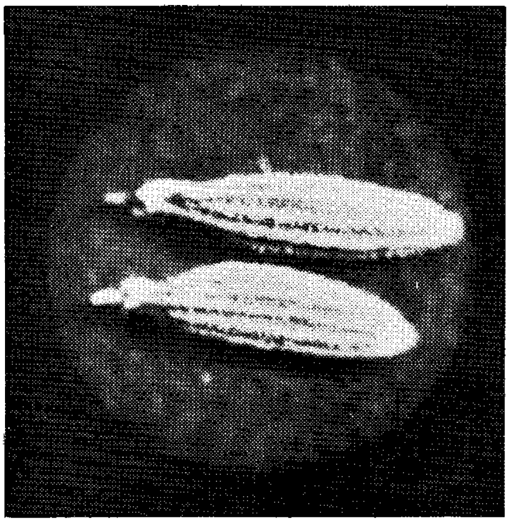

Fig. 20. Cumin Seed × 7½.

Malta, Cyprus, Argentina, and India. In recent times, most of the cumin imported into the United States of America has come from Iran and Morocco.

Cumin is a low-growing plant with finely divided leaves, and small, white flowers borne in terminal compound umbels. The fruit consists of two united carpels, each carpel containing a single seed. The plants are harvested when the fruits are mature, and stacked in the field to air dry. They are then threshed.

Cumin Seed

The dried fruit, commonly called cumin seed, consists of united or separate carpels. The carpels vary in length from about 1/8 to 1/4 inch. They are elongated-oval in shape and yellowish-brown in color. A sample of cumin seed consists of united and separate carpels. Cumin seed has a distinctive, heavy, strong odor, and a warm, aromatic taste.

Cumin seed is available whole or ground. It is used to flavor soups, rice and meat dishes, and bread. Commercially, it is employed in the manufacture of processed meats, chutney, pickles, and cheese. Ground cumin seed is an ingredient of curry powder.

CURRY POWDER

Curry powder is not the ground product of a single spice but of many spices. The basic ingredients are usually turmeric, coriander, cumin and fenugreek, to which is added some or all of the following spices: cayenne pepper, ginger, cardamom, allspice, cloves, fennel, black or white pepper, depending upon the culinary purpose for which the curry is to be used and whether a "hot" or "mild" curry is preferred. Formulae vary, as do the proportions, with different manufacturers.

Many delightful dishes can be prepared with curry powder including curried rice, meats, chicken, fish, and eggs. A little curry powder added to soups and stews will give them an added note of flavor.

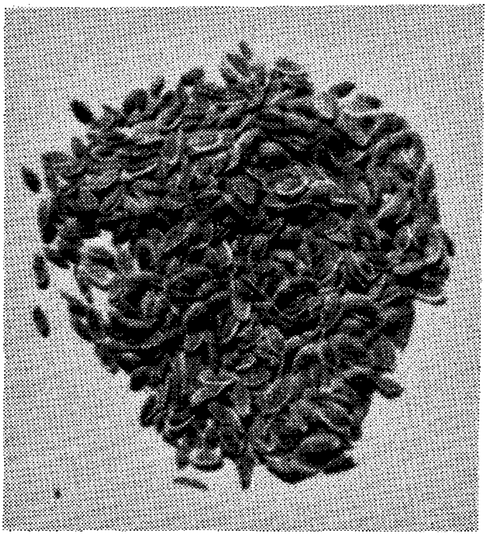

Fig. 21. Dill Seed.

DILL

Dill is the dried fruit of *Anethum graveolens* L., an annual herbaceous plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley famlly). The dill plant is native to Mediterranean countries and southern Russia. It is cultivated in England, Germany, Denmark, Holland, Rumania, India, Mexico, Canada, and the United States of America.

The dill plant reaches a height of three to four feet. It has an erect, branching stem, finely divided green leaves, and small, bright yellow flowers borne in terminal compound umbels. The fruit consists of two united carpels, each carpel containing a single seed. All parts of the plant are aromatic. As the fruits begin to ripen, the plant turns a purplish-red. All the fruits do not ripen at the same time, and since fully ripened fruits fall easily from the

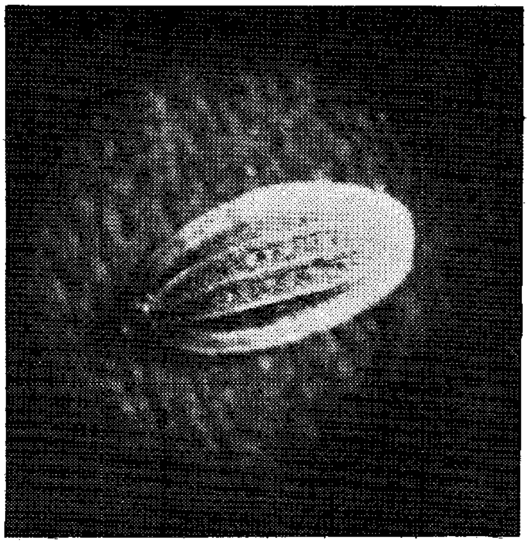

Fig. 22. Dill Seed × 7½. (Note Broad Lateral Ridges.)

plant some are unavoidably lost. This presents a problem in harvesting. Some growers believe it best to mow the crop when the earliest fruit is ripe, allowing the unripe fruits to mature on the plants before threshing. Others believe the maximum yield of fruit is best obtained by waiting as long as possible before mowing and threshing.

Dill Seed

The fruit, commonly called dill seed, consists of united or separate carpels. The carpels are light brown in color, oval in shape with two broad lateral wings, and vary in size from about 3/32 to 3/16 inch in length. A sample of dill seeds consists of united and separate carpels. The flavor of dill seed is warm, slightly sharp, and faintly reminiscent of caraway.

Dill seed is available whole or ground. It is used to flavor soups, meat dishes, meat and fish sauces, salads, and pickles. It is employed commercially in the preparation of pickles, and to flavor processed meats, fancy sausages and bologna.

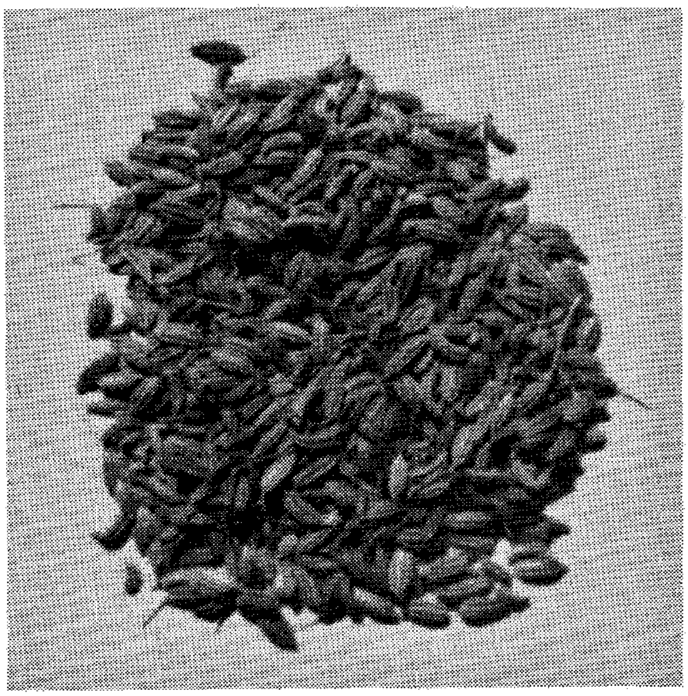

Fig. 23. Fennel Seed.

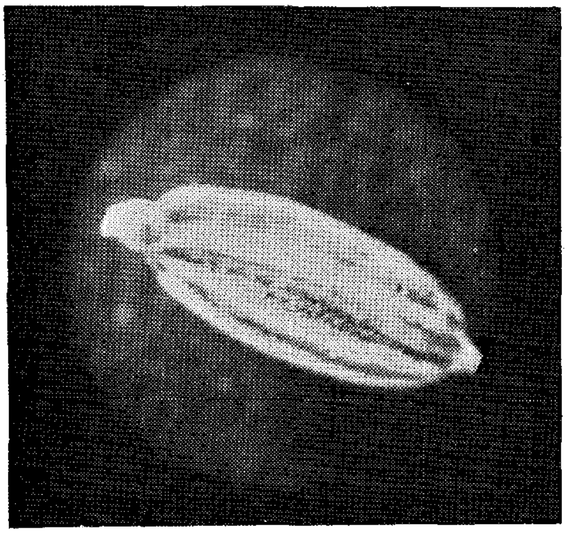

Fig. 24. Fennel Seed × 7½.

FENNEL

Fennel is the dried fruit of *Foeniculum vulgare* Miller., a biennial or perennial herbaceous plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley family). The fennel plant is native to southern Europe and Asia Minor. It is cultivated in Germany, France, Italy, Denmark, Holland, Rumania, Bulgaria, North Africa, Syria, Russia, India, Japan, Argentina, United Kingdom, and the United States of America. In recent times, most of the fennel seed imported into the United States has come from India.

The fennel plant reaches a height of three to five feet. It has green stems and feathery, finely divided green leaves. The flowers are small, yellow, and borne in terminal compound umbels. The fruit consists of two united carpels each carpel containing a single seed. All parts of the plant are aromatic. The plants are harvested when the fruits are mature, air dried, and threshed.

Fennel Seed

Dried fennel fruit, commonly called fennel seed, is green or yellowish-brown in color, oblong-oval in shape, bold, with prominent ridges, and varies in size from about 5/32 to 5/16 inch in length. Fennel seeds have a pleasing aroma and taste very suggestive of anise.

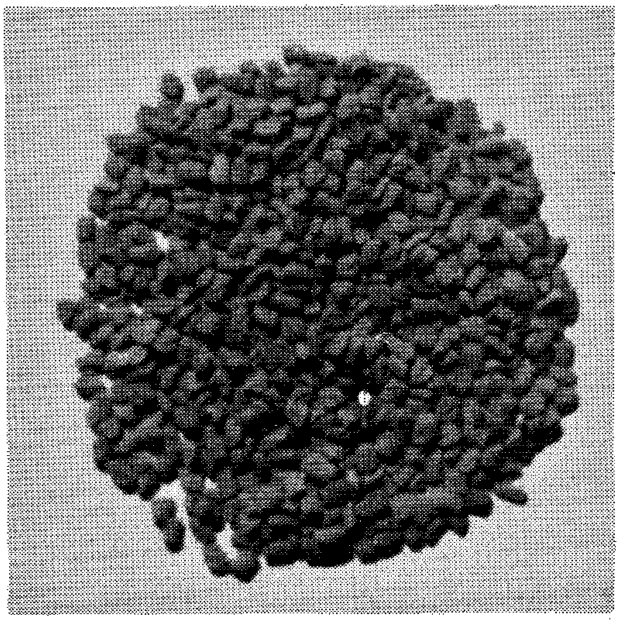

Fig. 25. Fenugreek Seed.

Fennel seed is available whole or ground. It is used to flavor soups, fish dishes, sauces, pickles, bread, rolls, pastries and confections. A small quantity of ground fennel seed is usually included in the preparation of curry powder.

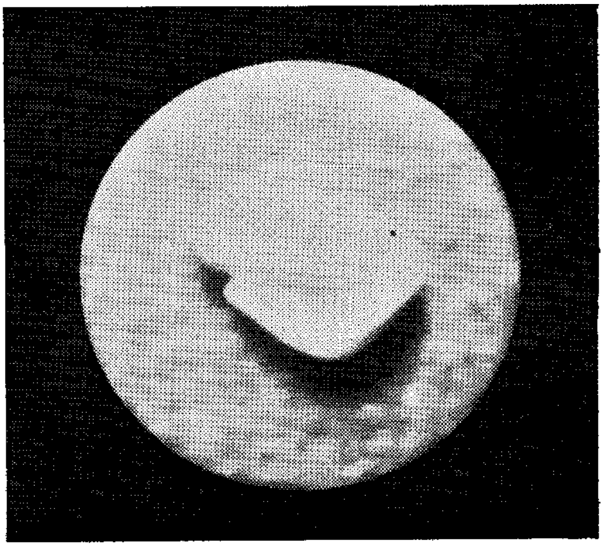

Fig. 26. Fenugreek Seed × 7½. (Note Deep Furrow.)

FENUGREEK SEED

Fenugreek seeds are the product of *Trigonella foenum-graecum* L., an annual herbaceous plant belonging to the *Leguminosae*, or Pea family, and native to southern Europe.

Fenugreek is cultivated in France, Lebanon, Morocco, India, and Argentine. The plant reaches a height of about two feet, and has light-green leaves and small, white flowers. The fruit consists of long, narrow, curved pods terminating in long, slender points. The seeds are yellowish-brown, flat, almost square-shaped, each marked with a deep furrow. They have an aroma reminiscent of burnt sugar, and a mealy taste.

Fenugreek seeds are available whole or ground. They are used in the preparation of imitation maple extract, pungent mango chutney and green mango chutney. The ground seed is an ingredient of curry powder.

GARLIC

Garlic is the compound bulb of *Allium sativum* L., a perennial plant belonging to the *Liliaceae*, or Lily family. It is indigenous to Europe and enjoys almost universal cultivation.

The compound bulb consists of a number of wedge-shaped bulblets, often called "cloves." The leaves of the garlic plant are long, narrow, flat, and sheath the lower part of the stem. The flowers are purple in color and produced in a cluster at the termination of the stem.

The spice consists of (1) garlic powder, which is the ground product of dehydrated cloves of garlic, and is a creamy-white powder with a strong, persistant aroma and taste; and (2) garlic salt, which is the ground dehydrated garlic mixed with free-running table salt and sometimes with a small quantity of edible starch to prevent caking. In addition to the above, minced dehydrated garlic is now available.

Garlic spice products have innumerable culinary uses including the flavoring of soups, meats, gravies, sauces, salad dressings, and garlic bread. Garlic salt goes well with tomato juice, and on steaks, stews and other meat dishes.

Garlic powder is employed commercially in the processing of fancy meats and sausages.

Garlic spice products readily absorb moisture and their containers should be tightly capped when not in use.

GINGER

Ginger is the dried rhizome or underground stem of *Zingiber officinale* Roscoe, an herbaceous perennial belonging to the *Zingiberaceae*, or Ginger family, and believed to be native to southeastern Asia.

Ginger is cultivated in Jamaica (West Indies), Nigeria, Sierra Leone (Africa), India, Ceylon, Indonesia, China, and Japan.

The ginger plant is propagated by division of the rhizomes. The rhizomes send up erect, leafy stems from one to three feet high. The base of the leaves sheath the stem. The leaves are light green in color, from six to eight inches long, narrow, lance-shaped, terminating in a sharp point, and with a prominent midrib. The flowers are small, yellowish, speckled, each with a purple, speckled lip, and borne in a spike terminating a separate, leafless stem.

When the plants are about nine months old the green leafy stalks begin to turn yellow and wither. The annual growth is then obviously over and the rhizomes are ready for harvesting. The rhizomes are carefully lifted with a fork and cleaned of all soil and adhering roots.

The method of preparation of dried ginger varies in the different countries of production.

Ginger not divested of cork—known as "unscraped" ginger—consists of rhizomes that have been cleaned, scalded in hot water, and dried in the sun.

Ginger divested of cork—known as "scraped" ginger—consists of rhizomes from which the epidermis and cork layers have been removed. Scraping or peeling is carefully performed to avoid cutting too deeply into the rhizomes, resulting in a partial loss of aromatic qualities derived from the essential oil secreted in the tissues beneath the cork. The scraped rhizomes are washed in clean water and then spread thinly and evenly on mats to dry in the sun.

In the spice trade, the varieties of ginger are named for the place of their production—for example, Jamaica ginger, African ginger, Japanese ginger,

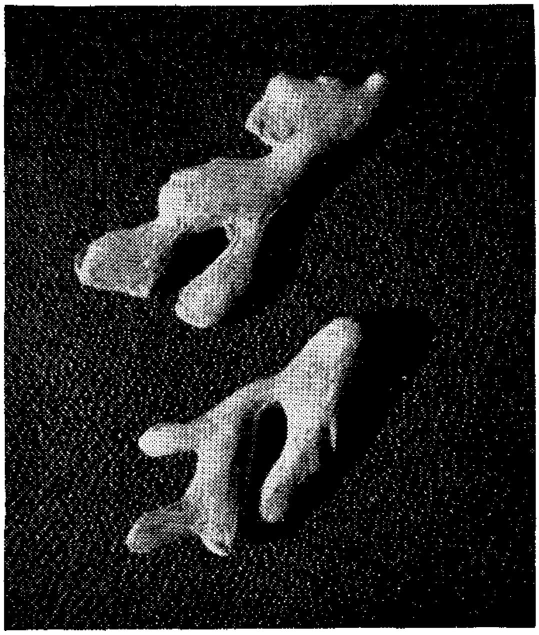

Fig. 27. Jamaica Ginger.

and Indian ginger (Cochin ginger, Calicut ginger). These gingers, as exported, differ in appearance, color, and size of the pieces or "hands" as they are called in the trade. Some are free of cork, some have part or all of the cork; some are a very light buff in color some are dark yellow to light brown, some are light brown with dark brown patches; some consist of hands about 2½ inches in length, and some to about four inches. The degree of aroma and pungency also varies.

The aroma of good quality ginger is agreeable, the taste aromatic and pungent.

Ginger is available whole, cracked (mechanically broken into smaller pieces), or ground. Industrial users can obtain from spice millers the ground product of any variety of ginger or a blend of varieties according to their particular needs.

Ginger is employed to give flavor and pungency to numerous foods including pies, cookies, cakes, biscuits, gingerbread, puddings, preserves, and beverages. Cracked ginger is an ingredient of whole mixed pickling spice, and ground ginger is a constituent of curry powder, mincemeat spice, pastry spice, and other ground spice flavoring and seasoning mixtures.

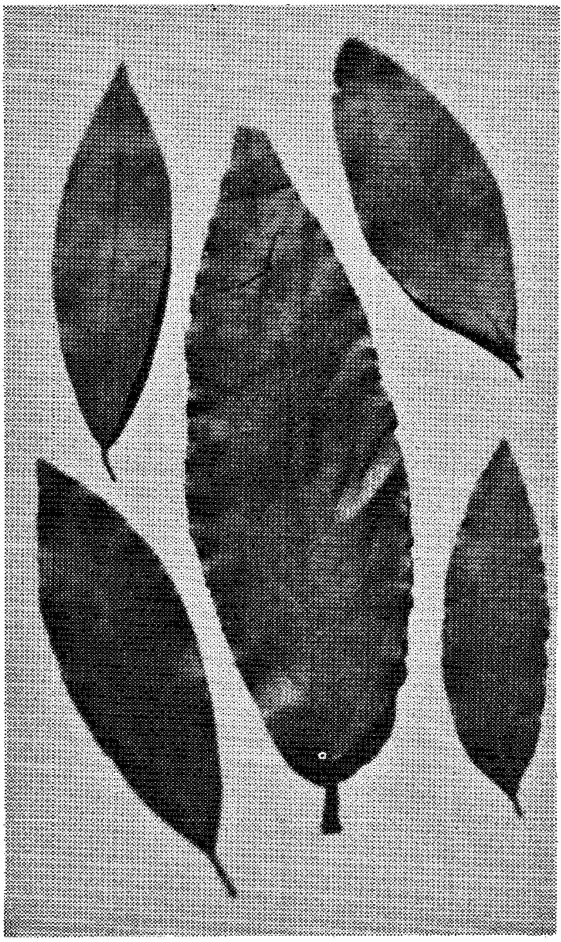

Fig. 28. Laurel Leaves.

LAUREL LEAVES

Laurel leaves, also known as Bay leaves, are obtained from *Laurus nobilis* L., an evergreen tree belonging to the *Lauraceae,* or Laurel family, and indigenous to countries bordering on the Mediterranean.

The Laurel tree, also called the Sweet Bay tree, is cultivated in Turkey, Greece, Yugoslavia, Spain, Portugal, France, Morocco, Mexico, and Guatemala.

The leaves are smooth, lustrous, deep green on the upper surface, paler on the lower, elliptical in shape, and varying in size. The flowers are yellow and the fruit is a purple berry. Only the leaves are employed as a spice.

The dried leaves are stiff in texture, but brittle. The color is greenish-brown to light brown on the upper surface, paler on the lower. The whole leaves have an agreeable odor. When the leaves are bruised or crushed they yield a very fragrant and aromatic aroma. The taste is aromatic and bitter.

Laurel leaves enjoy wide culinary use. They are employed to flavor meat, game, poultry, and fish dishes, soups and sauces. Cracked laurel leaves are an ingredient of whole mixed pickling spice.

MARJORAM

Sweet Marjoram

Marjoram consists of the dried leaves with or without a small proportion of the flowering tops of *Majorana hortensis* M., a perennial herbaceous plant belonging to the *Labiatae*, or Mint family. The marjoram plant is native to the Mediterranean region and western Asia. It is cultivated in France, Germany, Italy and other European countries, and in North and South America. Most of the marjoram imported into the United States comes from France. French marjoram is delightfully fragrant and held in high esteem.

Although a perennial, Marjoram is commonly grown as an annual. It is an erect, branching, sun-loving plant about twelve inches high with ovate-shaped, grayish-green, fragrant leaves and small, whitish flowers borne in terminal clusters. The plants are harvested as soon as they have flowered. Methods of drying depend upon the size of the crop and the climatic conditions in the producing countries. The cut plants may be tied in bunches and dried in the open air, or spread on wire trays in ventilated rooms and dried by controlled, circulating warm air.

The aroma of dried marjoram is fragrant, the taste aromatic, warm, slightly sharp and somewhat bitterish.

Dried marjoram is available whole or ground. It is an excellent flavoring agent for soups, stews, lamb and mutton, sausage, egg dishes, vegetables, and poultry dressing. Commercially, marjoram is employed to flavor a number of fancy meats and sausages.

MINT

There are several species of cultivated mint, but the two that consitute the dried mint of the spice merchant are Peppermint and Spearmint.

Peppermint consists of the dried leaves and flowering tops of *Mentha piperita* L.; Spearmint, those of *Mentha spicata* L. Both are perennial herbaeous plants belonging to the *Labiatae*, or Mint family, and both are native to Europe and Asia. Peppermint and spearmint are cultivated in all parts of Europe, in some parts of Asia, in the United Kingdom, and in North and South America. Most of the dried mint sold in the United States is grown domestically.

The two plants are much alike. Both have erect stems and ascending branches, those of the spearmint a little more so than the peppermint. The leaves of the peppermint are ovate, sharply toothed, and dark green; those of the spearmint are similar in shape but slightly longer and narrower than peppermint, not so sharply toothed, and a lighter green in color. The flowers of both plants are small and purple in color; those of the peppermint are borne in terminal spikes and in clusters in the upper leaf axils, those of the spearmint in whorls arranged upon interrupted, terminal spikes. Both plants have prolific creeping stolons.

The plants are harvested when in bloom. Generally, they are allowed to partially dry in the open for a short period of time and the drying completed indoors by a process of carefully controlled, circulating warm air, avoiding overheating and too slow drying. When the leaves have attained the desired degree of brittleness they are stripped from the stems, allowed to dry out completely, and then rubbed through a wire sieve or fragmented mechanically.

Dried peppermint has a characteristic, sweetish, strong aroma, and an aromatic, warm, pungent taste, with a cooling after taste; spearmint to a lesser degree with no cooling after taste.

Mint is used to flavor soups, stews, meat and fish sauces, salads, mint jelly, mint sauce, mint drinks, and confections.

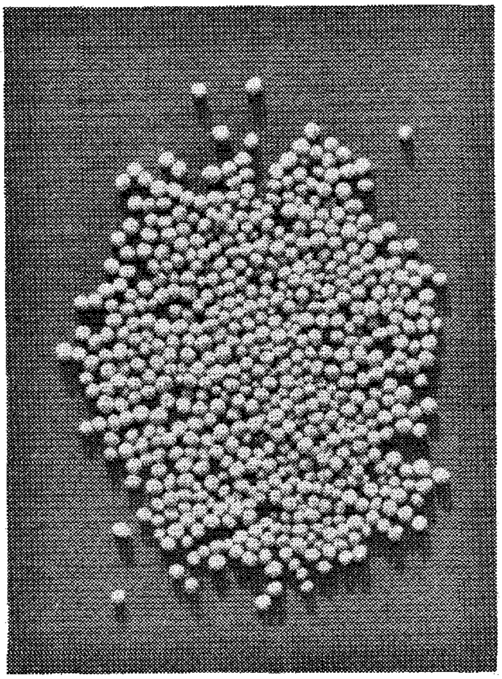

Fig. 29. Yellow (White) Mustard Seed.

MUSTARD

In spices, the term mustard refers to the seeds of two different plants of the

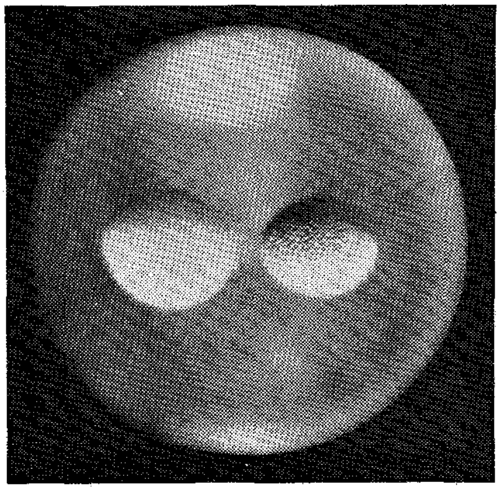

Fig. 30. Mustard Seed × 7½. *Left:* White (or Yellow). *Right:* Black (or Brown).

same family—namely, *Sinapis alba* L., from which is obtained white mustard seeds, and *Brassica nigra* (L.) Koch (also named *Sinapis nigra* L.) from which is obtained black mustard seeds. The former is commonly known as yellow mustard and the latter as brown—understandable terminology when the color of the respective seeds is considered.

Both plants belong to the *Cruciferae*, the name being derived from the cross-like figure formed by the four petals of the flower, or Mustard family.

The white mustard plant is native to southern Europe and western temperate Asia; the black mustard plant is native to central and southern Europe and western temperate Asia.

Both plants are cultivated in many parts of the world including Denmark, Holland, Germany, Austria, Italy, North Africa, India, Chile, United Kingdom, United States of America, and Canada. Most of the mustard seed imported into the U.S.A. in recent times has come from Canada.

The white mustard plant is a herbaceous annual reaching a height of about two feet. The lower leaves are cleft or parted, the upper leaves are cut somewhat into two lower lobes and a larger terminal lobe. The leaves are irregularly toothed, hairy, and somewhat tough. The flowers are small, yellow, and borne in racemes. The fruit is a cylindrical, bristly pod with a long, sword-shaped beak. The seeds are small, nearly globular, and yellowish in color.

The black mustard plant is also an herbaceous annual, reaching a height of two feet or more. The lower leaves are large, with two lower lobes and a large terminal lobe, the central leaves are moderately lobed, and the uppermost leaves are entire and narrow. The lower and central leaves are irregularly toothed. The flowers are similar to those of the white mustard plant. The fruit is a four-sided pod with a short beak. The seed is smaller than the white mustard seed, nearly globular, and dark reddish-brown in color.

The dry mustard seeds of either plant have no perceptible odor; the taste of the seeds of both plants is pungent.

Whole mustard seeds are employed in the preparation of pickles of various kinds. They are an ingredient of whole mixed pickling spice. Ground mustard is used in the preparation of mustard pickles; in the manufacture of prepared mustard—a preparation of ground mustard, white vinegar, a number of other ground spices, and salt; and in the preparation of mustard sauce, sea food sause, mayonnaise, and salad dressings. The table condiment often referred to as "hot" or "English" mustard is the product of a blend of ground white (yellow) and black (brown) mustard seeds.

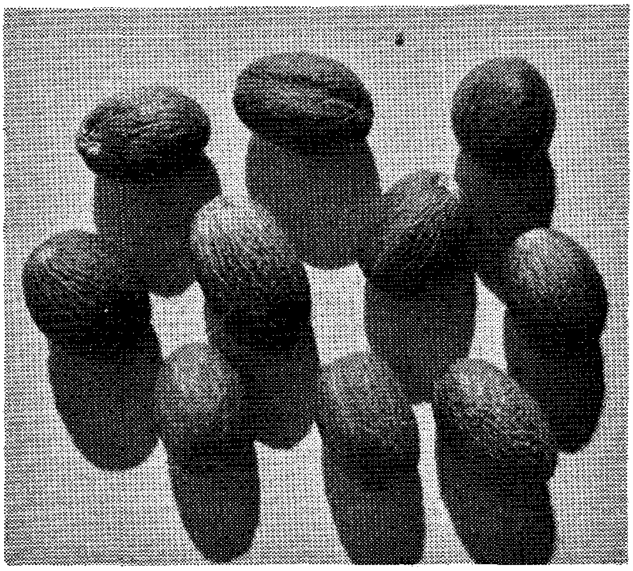

Fig. 31. Nutmegs.

NUTMEG and MACE

Nutmeg and mace are products of the same tree. Nutmeg is the seed and mace is the aril of the fruit of *Myristica fragrans* Houtt., an evergreen tree belonging to the *Myristicaceae*, or Nutmeg family, and native to the Moluccas or Spice Islands (Indonesia).

Nutmeg trees are cultivated in Indonesia, Malaysia, West Indies, and some other tropical or sub-tropical parts of the world. The plants are propagated from seed planted in well prepared nursery beds. The seeds germinate in four to six weeks, and when the young plants reach six to nine inches in height they are transplanted to the field and spaced twenty to thirty feet apart. Once they are established the plants require little care and pruning is seldom necessary. The nutmeg tree is normally unisexual—that is, male and female flowers are borne on separate trees. Since fruit comes only from female flowers growers endeavor to maintain a ratio of one male tree to ten or twelve female to effect satisfactory pollination and to achieve maximum production from the plantation.

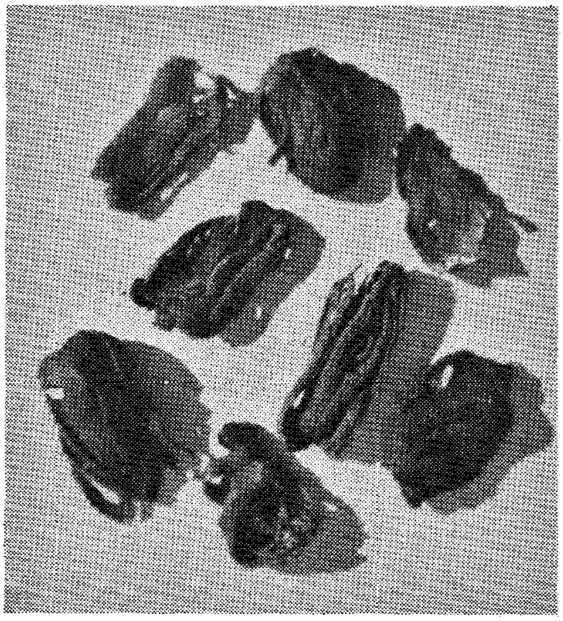

Fig. 32. True Mace. (Grenada.)

The nutmeg tree attains a height of thirty to forty feet or more and has spreading branches. The leaves are oblong-ovate in shape, four inches or more in length, of leathery texture, dark green and lustrous. The flowers are small, fleshy, pale yellow and fragrant. The male flowers are borne in clusters, the female flowers, which are larger than the male, are usually solitary. The fruit is a pendulous, fleshy drupe, smooth, pale orange-yellow in color, and with a groove running down one side. When ripe, the pericarp or "husk," opens by splitting from the top along the groove into two halves nearly to the base. Within the husk is the seed—the nutmeg—contained in a deep brown, lustrous seed coat or shell, and enveloped in an aril, a crimson-colored, somewhat tough, leathery, protective membrane developed in narrow, pointed lobes attached to the base of the seed—the mace.

Nutmeg trees usually begin to bear fruit in the fifth or sixth year but may take eight or nine years. They reach maximum productivity when fifteen years old and continue to yield for a further ten to twenty years.

As soon as the fruits split or are about to do so, they are collected from the trees by hand, the pickers using a specially constructed hooked bamboo stick on higher branches, or the nutmegs are allowed to fall to the ground from the mature husks. The latter method is preferred in Grenada (West Indies) where it is considered unsound to "reap" nutmegs from the trees, and where the growers are urged to gather only freshly fallen nutmegs, or under favorable weather conditions within twenty-four hours of their fall.

The nutmegs are taken to curing houses where the mace is carefully removed and the nutmegs and mace are dried separately. The drying of nutmegs is a slow process if it is to be accomplished efficiently, involving exposing them to the sun for limited daily periods and turning them twice daily over a period of six to eight weeks. When the nutmegs are dry they rattle in the shell or seed coat on shaking. The shell is removed by breaking with the aid of a wooden truncheon or by mechanical means.

The mace is flattened by hand or between boards. It is then dried by exposure to the sun for varying daily periods. In drying, the color changes from its natural crimson to a pale yellow or buff color, and the spice becomes horny and brittle.

Nutmeg has a characteristic, aromatic odor, and an aromatic, warm, slightly bitter taste.

Mace has a fragrant, nutmeg-like odor, and an aromatic, slightly warm taste.

Nutmegs are available whole or ground. The culinary uses for nutmeg include the flavoring of sweet dishes, pies, puddings, toppings, some meat and vegetable dishes, and beverages. It is an ingredient of a number of prepared ground spice mixtures including mincemeat spice, pastry spice, poultry dressing, sausage, bologna, and frankfurter seasonings.

Mace is available whole, broken, or ground. It is used to flavor cakes, biscuits, preserves, sauces, pickles, meat and fish dishes. It is employed in the commercial manufacture of a number of foods including relishes, sauces, and some fancy meats. It is an ingredient of mincemeat spice, poultry dressing, pork sausage spice, and other ground spice flavorings and seasonings.

ONION

Onion is the bulb of *Allium cepa* L., a biennial plant belonging to the *Liliaceae*, or Lily family. Its nativity is not definitely known but it is believed probable that it originated in the eastern Mediterranean reagion and the Middle East. Its cultivation is widespread in temperate and tropical regions.

The leaves of the onion plant are dark green, long and tubular. The flowers are white or greenish-white, produced in a globular head or cluster at the termination of a tubular stalk.

The spice consists of (1) onion powder, which is the ground product of dehydrated onion bulbs, and is a creamy-white powder with an aroma and taste similar to that of the fresh onion; and (2) onion salt, which is the ground dehydrated onion mixed with free-running table salt and, sometimes, with a small quantity of edible starch to prevent caking. Flaked and minced dehydrated onion have been added to the spice shelf.

All of the above products may be employed in the culinary art in the place of fresh onions. In addition, onion salt used with or in the place of table salt adds flavor to meats, gravies and sauces. Onion powder is employed commercially in the processing of fancy meats and sausages.

Onion spice products are effective, labor-saving, and convenient for both kitchen and outdoor cooking. They readily absorb moisture and their containers should be tightly capped when not in use.

ORIGANUM

Origanum, also called Oregano, Mexican sage, consists of the dried leaves and flowering tops of a variety of *Origanum vulgare* L., a perennial herbaceous plant belonging to the *Labiatae*, or Mint family. Origanum is indigenous to the Mediterranean region and Western Asia. It is cultivated in many parts of the world including Spain, France, Italy, Yugoslavia, Albania, Greece, Turkey, and Mexico.

The origanum plant reaches a height of one to two feet and has ovate-shaped, light green leaves and small, purplish flowers borne in clusters on short spikes. Although a perennial, origanum is usually grown as an annual.

Dried origanum has a strong, aromatic odor, and a warm, pungent, bitter taste. It is used to flavor soups, meat, fish, and egg dishes, meat sauces, chili con carne, and other dishes. It is found in every Mexican kitchen, where it is highly esteemed for its aroma and flavor. Ground origanum is an ingredient of Mexican chili powder.

PARSLEY

Parsley consists of the dried leaves of *Petroselinum sativum* Hoffm., a biennial herbaceous plant belonging to the *Umbelliferae*, or Carrot family (also called the Parsley family). The parsley plant is believed to be a native of Sardinia. It has been grown in England since the middle of the sixteenth century and has become naturalized in the United States of America. Parsley is extensively cultivated throughout Europe and North America.

The parsley plant is low-growing and yields a profusion of bright green, segmented, curly leaves in the first year. The flowers, produced in the second year, are small, white and borne in compound terminal umbels. Under cultivation, parsley is usually grown as an annual and will produce several crops of leaves. The fresh leaves are dried rapidly under controlled conditions of heat and air to avoid loss of the essential oil that gives the herb its characteristic flavor and to ensure a good green color.

Dried parsley has an agreeable, characteristic odor and taste. Its culinary uses are numerous including the flavoring of soups, meat and fish dishes, sauces and vegetables.

PEPPER

Pepper is the dried fruit of *Piper nigrum* L., belonging to the *Piperaceae* or Pepper family. It is a perennial vine indigenous to the Malabar coast of southern India.

The leaves are large, ovate, leathery, smooth, without marginal serrations or teeth, and dark green. The flowers are small, whitish, and borne on hanging catkins or, more properly, spikes. The fruits, commonly called berries or peppercorns, are small, nearly spherical, and dull green in color when immature, turning yellowish, and finally red as they ripen.

The plants grow best in well drained soil rich in humus, and flourish in a warm, moist climate. Newly cleared jungle land is held to be well suited.

Pepper plants are normally propagated from cuttings 18 to 24 inches long and showing roots at the nodes, taken from the top of vigorous heavy yielding vines. Cuttings from the horizontal shoots arising from the base of the old vines can be used but they are not recommended. Cuttings from side branches are never used.

Usually, the cuttings are planted in friable soil in nursery beds where they remain for three or four months to develop sufficiently strong root systems. They are then lifted during rainy weather and planted in their permanent site in the field. Cuttings can be planted directly in the field, but this method is said to meet with only limited success.

Pepper plants can be raised from seed but the seedlings take around eighteen months to be ready for planting out and may take over five years to bear. Vines raised from cuttings bear in about three years.

The vines are trained to living trees or to hardwood supports. The latter is the more common method. The wood supports vary in height and spacing in different countries. For example, in Asia they may be 10 to 14 feet high and spaced 7 to 8 feet apart with the same distance between the rows; in Brazil they are from 8 to 10 feet high and spaced from 8 to 10 feet apart. It is said that yields from vines trained to hardwood supports are better than those obtained from vines trained to living supports.

The vines are pruned back seven or eight times to encourage productive

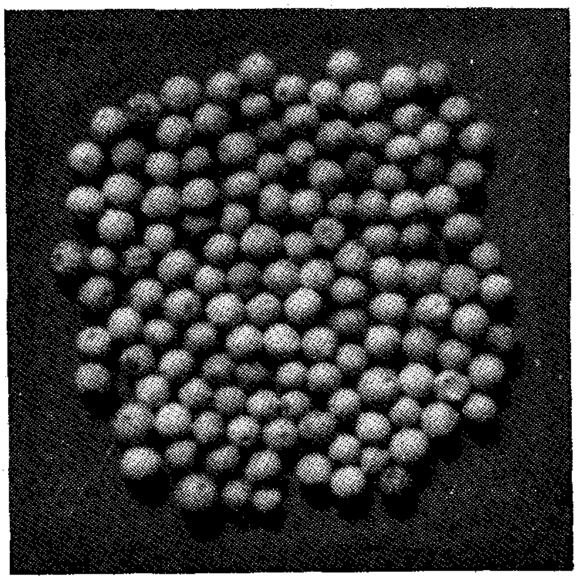

Fig. 33. White Pepper.

side branches and to keep the plant low for easy harvesting.

As the vines age, the yield of pepper increases, and give maximum yields from the eighth to twelfth year. The yields then gradually decline, falling off considerably after twenty years.

When the berries begin to turn red the spikes are picked from the vines. The collected spikes are beaten lightly with sticks or rubbed by hand to separate the berries from the stalks, which are removed by winnowing.

The berries are then prepared for market. In Asia it is the practice to steep the berries in boiling water for about ten minutes and then spread them on mats to dry in the sun. Drying is carried out as rapidly as possible to prevent mold growth, and with good sun the process is complete in three to four days. The hot water treatment makes the skin turn black in an hour. The end product is dried black pepper.

White pepper is prepared by keeping ripe berries in moist heaps for two or three days, or by soaking the berries, contained in gunny sacks, in running water for seven to eight days to soften the outer pericarp, or outer coating as it is commonly called. The process of removing the outer part of the pericarp begins with trampling the berries under foot, after which they are placed in rattan baskets and washed and rubbed by hand to remove the pulpy covering and stalks. The berries are then spread out on mats in the sun for a day or two to dry. The resultant "white" berry is actually a light yellowish-gray in color and consists of the seed coated with the inner part of the pericarp.

White pepper can also be prepared by mechanical abrasion of dried black peppercorns. This process permits the manufacture of various grades de-

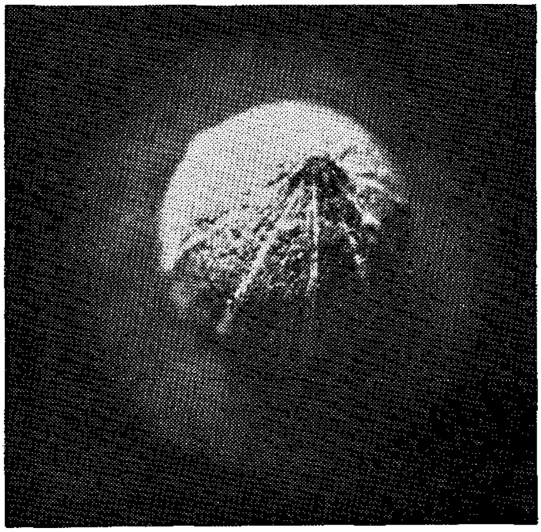

Fig. 34. White Pepper × 7½.

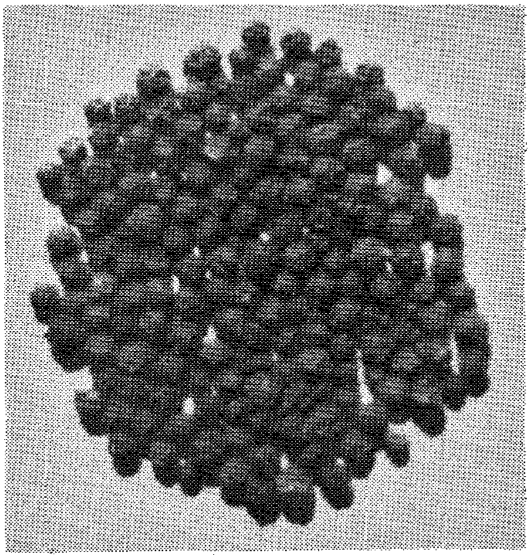

Fig. 35. Black Pepper.

pending upon the length of time of attrition. Part of the pericarp of the black peppercorn or all of it can be removed. The resultant product is known as "decorticated white pepper." This pepper is preferred by food manufacturers in the production of such preparations as mayonaise and salad dressings where black specks are undesirable.

Pepper is cultivated in many tropical and subtropical parts of the world including India, Ceylon, Malaysia, Indonesia, Thailand, Malagasy Republic, and Brazil.

Brazil is a recent producer of pepper. The cultivation of pepper in Brazil began with cuttings brought from Singapore by Japanese emigrants in 1933 and planted in the municipality of Tomé Açu in the state of Pará. By 1959 pepper plantations had extended to other areas of Pará, and today there are over 8,000,000 pepper plants under cultivation. Beginning in 1936, three years after the introduction of the first cuttings, pepper production has steadily increased to reach 11,000 tons in the year 1967, and this is expected to increase with the development of new plantations.

The soil and the tropical climate of the state of Pará is well suited to the cultivation of pepper. Methods of cultivation are similar to those followed in Asia. Vines produce their first commercial berries eighteen months after planting in the field. Harvesting is carried on from July to December.

The berries are gathered for the most part by women and children. The spikes are removed from the vines by hand and then threshed.

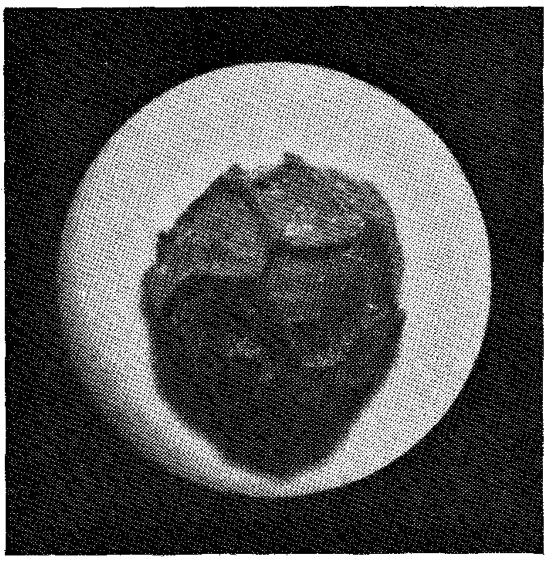

Fig. 36. Black Pepper × 7½.

In Brazil, black pepper is prepared by drying the berries in the sun (in the case of small producers) or in driers (large producers). To obtain white pepper the berries are soaked in water for eight days to loosen the outer coat (small producers) or the outer coat is removed by mechanical means and washing in water (large producers). The berries are then dried in the sun or in driers.

Brazilian pepper is graded No.1 and No.2. Producers claim that their product is equal to Asiatic pepper in color, size, and quality.*

The various kinds of pepper known to the spice trade are named for the districts in which they are produced or for neighboring ports through which they are exported. For example:

Lampong black pepper takes its name from Lampong, a district of southeastern Sumatra, Indonesia.

Sarawak black pepper takes its name from the former British colony of Sarawak, now part of Malaysia.

Ceylon black pepper takes its name from the island of Ceylon.

Alleppey black pepper is cultivated in the southern Malabar coast region of India and is named for the shipping port of Alleppey. Today, this pepper is generally known as "Malabar Alleppey."

Tellicherry black pepper is cultivated in the northern Malabar coast region of India and is named for the city of Tellicherry in Cannanore District of

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* Information on Brazilian pepper by courtesy of the President of Plantadores E Produtores De Pimenta Do Reino Do Pará S/A, Belém, Pará, Brasil.

Kerala, about 35 miles north-northwest of Calicut. Today, this pepper is generally known as "Malabar Tellicherry."

Brazilian black pepper takes its name from Brazil, where it is cultivated in the northern state of Pará.

Muntok white pepper is cultivated on the island of Bangka off the southeast coast of Sumatra, Indonesia, and is named for the shipping port of Muntok.

Both black and white pepper berries are imported whole by spice merchants who mill them to the requirements of the food processing industry and the retail food trade.

Both black and white pepper enjoy almost universal use. They are available whole, cracked, coarsely ground, or finely ground. Both have numerous culinary uses including the seasoning and flavoring of soups, meats, poultry, game, fish, eggs, vegetables, salads, sauces and gravies. They are employed by the food manufacturing industry in the preparation of processed meats of all kinds, soups, sauces, pickles, salad dressings, mayonaise, and other foods.

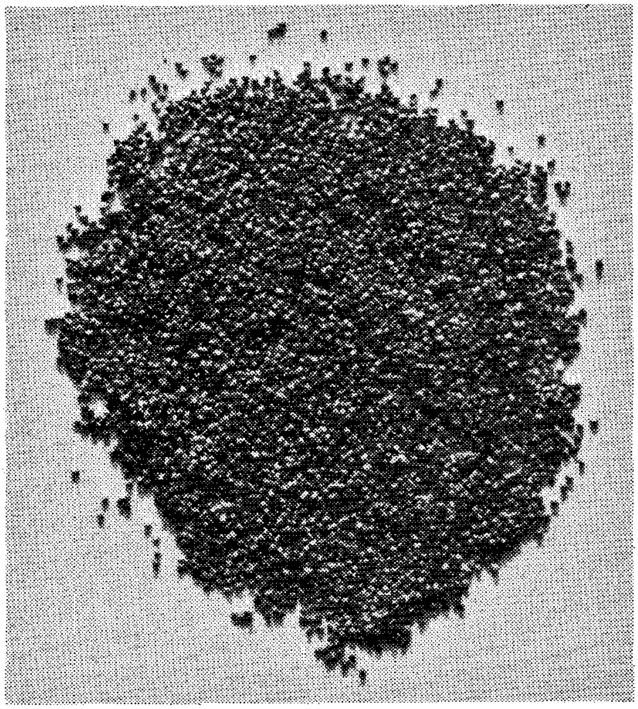

Fig. 37. Blue Poppy Seed.

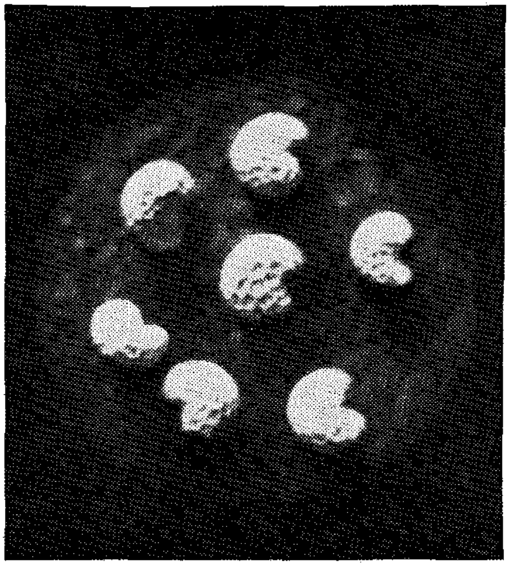

Fig. 38. Poppy Seed × 7½.

POPPY SEED

Poppy seed is the product of *Papaver somniferum* L., or Opium Poppy, an herbaceous plant belonging to the *Papaveraceae*, or Poppy family. It is indigenous to Asia, and cultivated in France, Germany, Hungary, Holland, Denmark, Poland, Czechoslovakia, Yugoslavia, Turkey, India, England, Canada, and the United States of America.

The plant is an annual, and reaches a height of about four feet. It has stout stalks and large, grayish-green, irregularly toothed leaves, clasping at the base. The flowers are large and showy, varying in color depending upon the variety, being white, pink, violet, red, or purple. The flowers are of short duration. The fruit consists of a large, globe-shaped capsule containing numerous very small, kidney-shaped seeds. Like the flowers, the seeds vary in color with the variety of the plant. The variety of *somniferum* known as the white poppy produces white seeds, that known as the black poppy produces slate-colored seeds, commonly called "blue." The seed commonly employed as a spice is the blue seed.

Although opium is derived from this plant the seeds are without narcotic properties.

Poppy seeds have a pleasing nut-like aroma and taste. They are used on cakes, pastries, cookies, bread, rolls, and confections.

ROSEMARY

Rosemary consists of the dried leaves of *Rosmarinus officinalis* L., a perennial shrub belonging to the *Labiatae*, or Mint family. Rosemary is native to the Mediterranean region. It is cultivated in Spain, Portugal, France, Germany, and other parts of Europe, and in the United States of America.

The rosemary plant is a small, evergreen shrub with an erect stem and many ash-colored branches. The leaves are green on the upper surface, whitish and wooly on the lower, slender and linear with the margin turned in toward the center of the underside. The flowers are small, blue, and borne in whorls produced in the axils of the leaves. The leaves are gathered when mature, and dried.

Dried rosemary leaves are fragrant, and yield an agreeable aroma when crushed; the taste is aromatic, pungent and bitterish. The dried herb is available whole or ground.

Rosemary is used to flavor soups, meat dishes, sauces, vegetables and salads.

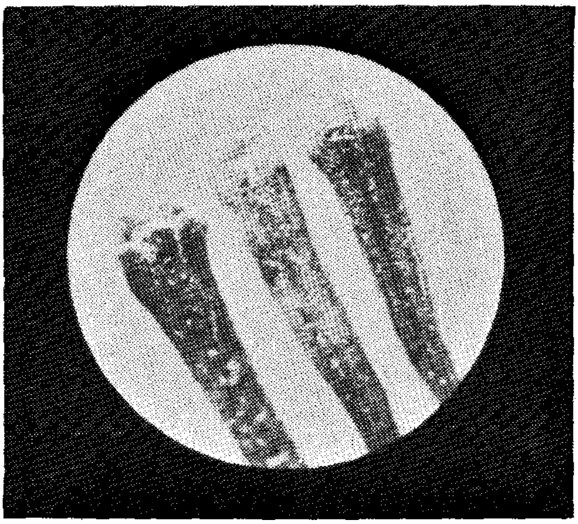

Fig. 39. Spanish Saffron × 7½.

SAFFRON

Saffron consists of the dried stigmas of *Crocus sativus* L., a perennial, low growing plant belonging to the *Iridaceae*, or Iris family. It is believed to be native to Greece, Asia Minor, and Iran (formerly Persia).

Saffron is cultivated in Spain, Portugal, France, Italy, India, England, and other countries.

The saffron crocus is propagated by corms produced by parent plants. It has six or more leaves which are narrow, dark green on the upper surface, and paler on the lower. The upper surface is marked with a central, longitudinal, white furrow. The flower is showy with three petal-like sepals, three petals, and pale reddish-purple in color. It has three stamens, and a yellowish style with three long, drooping, trumpet-shaped red stigmas.

The stigmas constitute the saffron spice of commerce. They are gathered by hand, the pickers detaching them from the style with a deft use of the thumb nail. The detached stigmas are spread on trays and dried with the aid of charcoal fires. They lose about eighty percent of their weight in drying, and it takes many thousands of them to provide an ounce of spice. Saffron has a characteristic aromatic odor and a bitter taste. It imparts a yellow color to water. An infusion of saffron and hot water is known as saffron tea.

Saffron is employed as a flavoring and coloring spice in confections, fancy rolls and biscuits, with rice, and in some European dishes such as chicken and rice, boiled fish, and fish soup.

SAGE

Sage consists of the dried leaves of *Salvia officinalis* L., a perennial shrub or subshrub belonging to the *Labiatae*, or Mint family. The sage plant is native to the Mediterranean region and grows profusely over the hillsides of the shores of southern Europe. It is cultivated in various parts of continental Europe including Spain, Italy, Yugoslavia, Greece, Albania, and Turkey; and in England, Canada, and the United States of America. Most of the sage imported into the United States in recent times has come from Albania, Italy, and the Dalmatian coast of Yugoslavia. Dalmatian sage is highly esteemed.

The sage plant reaches a height of about two feet and has a branching, woody stem with grayish-green leaves, more or less wooly according to variety, and small, blue flowers borne in whorls on long, terminal spikes. The leaves are gathered while the plants are in flower, dried in the shade or indoors by circulating warm air.

Dried sage has a fragrant aroma, and an aromatic, warm, slightly bitter taste. It is available whole, rubbed, or ground.

Dried sage is used to flavor pork and other meats, baked fish, and meat stuffings. Commercially it is employed in the preparation of fancy meats and sausages. Ground sage is an ingredient of poultry, sausage, and hamburger seasonings.

SAVORY

Savory consists of the dried leaves and flowering tops of *Satureia hortensis* L., an annual herbaceous plant belonging to the *Labiatae*, or Mint family. The savory plant is native to southern Europe where it grows spontaneously. It is cultivated in France, Spain, Germany, and other parts of continental Europe; and in England, Canada, and the United States of America. Most of the savory imported into the United States in recent times has come from France and Spain.

Savory, also called Summer Savory, is a low-growing plant with very small, green leaves. The flowers are small, pale-lilac in color and borne in clusters in the axils of the upper leaves.

The plants are cut down at flowering time and dried. In drying, most of the leaves fold upwards along the midrib.

Dried savory has a fragrant, aromatic odor, and a warm, aromatic, slightly sharp taste. It is available whole or ground, and is used to flavor soups, meat and poultry dishes, egg dishes, sauces, beans and peas, and salads. Ground savory is an ingredient of poultry seasoning.

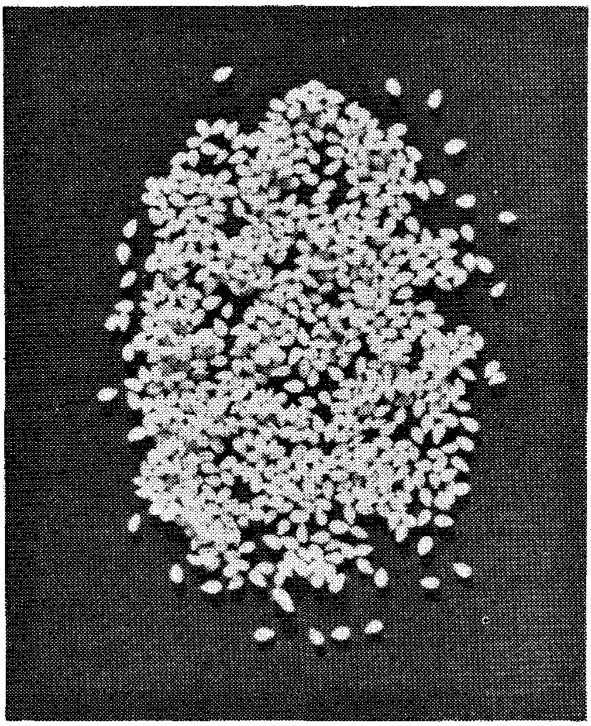

Fig. 40. Sesame Seed.

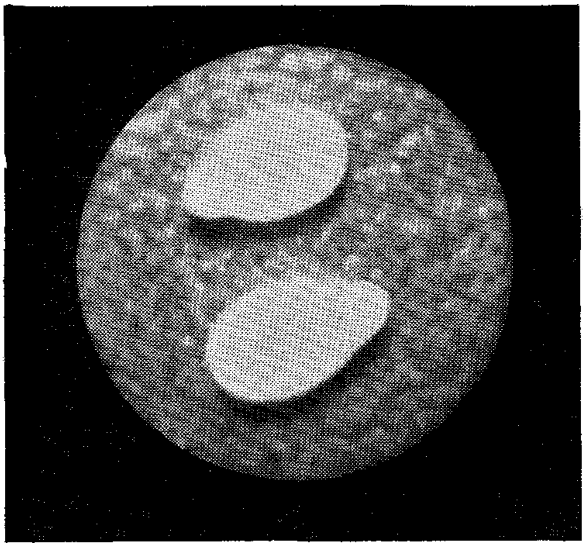

Fig. 41. Sesame Seed × 7½.

SESAME SEED

Sesame seeds are the product of *Sesamum indicum* L., (also known as the Benne plant), a herbaceous annual belonging to the *Pedaliceae*, or Sesamum family, and native to Asia.

Sesame has been grown in parts of Asia and Africa from time immemorial for food and for its oil, known as Sesame, Gingelly, Til, Sim, or Beni-seed oil. It is extensively cultivated in many parts of the world including Turkey, Greece, Lebanon, Egypt, Ethiopia, Kenya, Sierra Leone, Tanganyika, India, China, Japan, West Indies, Nicaragua, Salvador, Guatemala, Mexico, and to some extent in the southern United States of America.

The sesame plant grows from two to four feet or more in height. The leaves vary considerably in shape. The flowers are tubular, pale or white in color and are borne singly in the axils of the leaves. The fruit consists of an oblong two-celled pod containing flattish, pear-shaped seeds.

Unhulled seeds vary in color from yellowish-white to black through shades of brown. Hulled seeds (i.e. those from which the seed coat has been removed) are creamy or pearly-white in color. Unhulled seeds are available

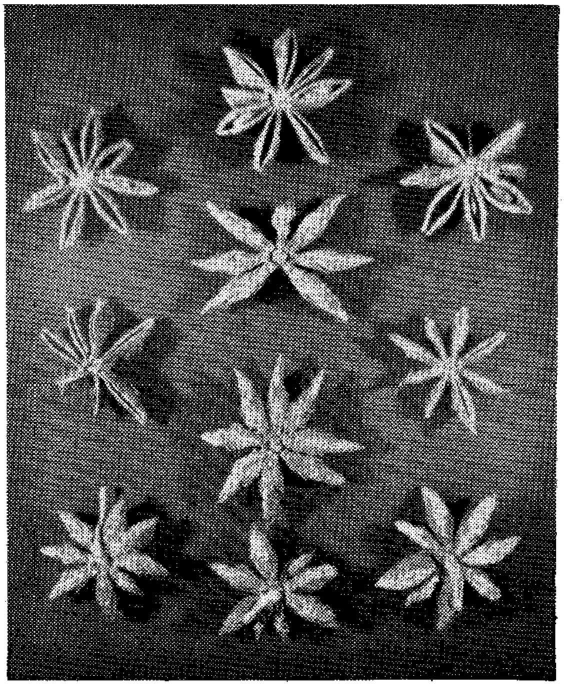

Fig. 42. Star Anise.

from spice merchants, but it is usually the hulled seeds that are sold to the North American consumer. They have an agreeable nutty taste and are used on biscuits, cookies, breads, rolls, and in confections.

STAR ANISE

Star anise is the dried fruit of *Illicium verun* Hook., an evergreen tree belonging to the *Magnoliaceae*, or Magnolia family, and indigenous to southeastern Asia. It is cultivated in southwestern China, North Vietnam, and in other neighboring sub-tropical parts.

The star anise plant is propagated from seed sown in nursery beds. The young plants are transplanted when about one year old and set out eighteen feet apart. The tree does not grow tall, ranging from about thirteen to twenty feet in height. The leaves are lance-shaped (but with the broadest part toward the apex) to elliptical. The flowers are greenish-yellow with several petals, and borne in the axils of leaves.

The fruit consists of a number of carpels, usually eight, arranged in a whorl around a central axis. The fruit takes its name from this eight-point star arrangement. Each carpel contains a single seed. The carpels are reddish-brown in color, hard, wrinkled, boat-like, and taper to a point. The inner part of the carpels is smooth and shiny. The seed is brown in color, compressed, smooth and lustrous.

The star anise tree begins to bear when about six years old and continues to yield until over one hundred years old. The fruits are collected before full maturity and dried in the sun.

The carpels of star anise have a pleasant, anise-like aroma, and an agreeable, highly aromatic, sweet anise-like taste. Star anise is available whole—it is not usually ground—and is used as a flavoring agent in confections.

SWEET BASIL

Sweet basil consists of the dried leaves of *Ocimum basilicum* L., an annual herbaceous plant belonging to the *Labiatae*, or Mint family. Sweet basil is native to India and Iran. It is cultivated in France, Italy, Hungary, Belgium, Poland, and other parts of continental Europe; in India and other parts of Asia, and in the United States of America. American growers produce considerable quantities of sweet basil for the United States domestic market. France is the leading producer of sweet basil imported into the United States.

Sweet basil is a low-growing plant with oval-shaped, green leaves. The flowers are small, and white, or bluish-white in color. The leaves vary in size according to the variety of basil cultivated, from the small leaves of the common basil to the large leaves of the lettuce leaf basil.

The fresh leaves can be dried in the open air, but more efficiently indoors by controlled artificial heat and circulating air. The dried leaves are reduced to specific sized fragments by a series of machines, and graded fine, medium, or coarse.

Dried sweet basil leaves have an aromatic, fragrant and sweet odor, and the taste is aromatic, warm, and mildly pungent.

Sweet basil is used to flavor soups, stews, tomato and vegetable dishes.

TARRAGON

Tarragon consists of the dried leaves of *Artemisia dracunulus* L., a perennial herbaceous plant belonging to the *Compositae*, or Composite family (also called the Sunflower family). The tarragon plant is believed to be a native of Siberia. There are two varieties of this species of *Artemisia*, one known as Russian tarragon, the other as French tarragon. The latter is the variety cultivated in the United States. Growers in the United States supply the requirements of the North American market.

The French tarragon plant has bright green, lance-shaped leaves. The flowers, not always produced, are small, very pale yellow in color, and generally sterile. French tarragon cultivated in the United States produces no flowers. The plants are propagated by root divisions and cuttings.

The leaves are dried indoors by artificial heat and circulating air carefully controlled to ensure retention of aroma and color. The dried leaves are then processed through a series of machines to provide particle sizes suitable to the needs of consumers.

Dried tarragon leaves have an agreeable aromatic odor and taste reminiscent of anise.

Tarragon is used to flavor meat, chicken, egg, and tomato dishes, sauces and salads. It is employed in the preparation of pickles, prepared mustard, tartar sauce, and in the manufacture of tarragon vinegar.

THYME

Thyme consists of the dried leaves and flowering tops of *Thymus vulgaris* L., a perennial shrub belonging to the *Labiatae*, or Mint family. Thyme is native to southern Europe and the Mediterranean region. It is cultivated in Spain, Portugal, France, Germany, Italy, and other countries of continental Europe; in North Africa, and in England, Canada, and the United States of America. Spain and France are the leading suppliers of thyme for the United States market, a small quantity comes from Portugal, and the balance is produced by American growers.

Thyme is a bushy plant from about twelve to eighteen inches high with ascending branches grayish-brown in the lower part and purplish in the upper, and small leaves, green on the upper surface, grayish on the lower, with the margin curled toward the lower side of the leaf. The flowers are small, pale purple in color, and borne in clusters in the axils of the upper leaves and in terminal clusters. The whole plant is aromatic.

The tops are harvested after the plants have come into full bloom. The clipped stems are carefully dried and stripped. The dried leaves have a fragrant, aromatic odor, markedly so when crushed, and an aromatic, warm, pungent taste.

Dried thyme is used to flavor soups, various meat dishes, fish dishes, sauces, tomato dishes, vegetables, and poultry dressing. Ground thyme is an ingredient of poultry seasoning.

TURMERIC

Turmeric is the dried rhizome of *Curcuma longa* L., a herbaceous perennial

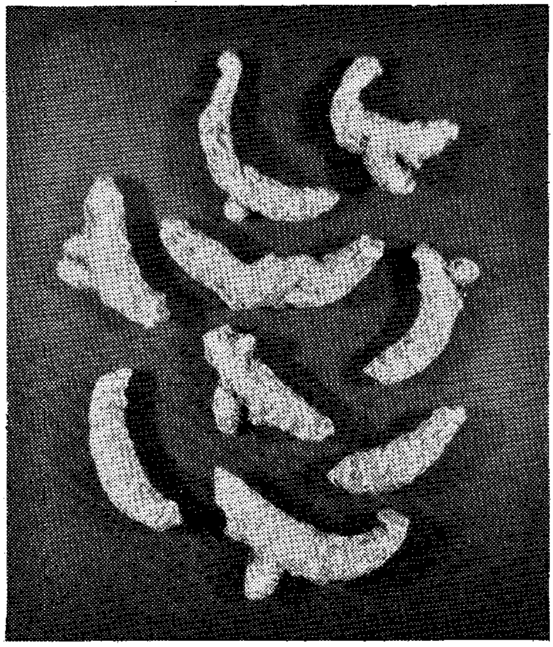

Fig. 43. Alleppey Turmeric.

belonging to the *Zingiberaceae*, or Ginger family, and native to southern Asia and Indonesia.

Turmeric is cultivated in India, Ceylon, Indonesia, China, Formosa, Peru, Haiti, Jamaica, and other tropical and sub-tropical lands.

The plant is propagated from "finger sets"—segmented portions of rhizomes, planted in well prepared beds. The rhizomes send up tufts of long, broad, lance-shaped, bright green leaves. The flowers are pale yellow, borne in dense spikes on separate stems shorter than the leaves.

About eight or nine months after planting the annual growth is over and the leaves turn yellow and wither. The rhizomes are then ready for harvesting. The plants are carefully lifted from the earth with a fork and the rhizomes are cut from the top growth. All roots are removed and the rhizomes washed to free them from adhering soil particles.

Methods of curing the rhizomes varies somewhat in the different countries of production, but in general are similar to that recommended in India and Ceylon. The rhizomes of the plant consist of "finger sets" (described above) and one or more stout tuberous portions known as "mother sets." It is the practice to split the latter sets lengthwise in four pieces. The prepared rhizomes are then placed in an earthern or metal vessel and just enough water added to cover the rhizomes. The remaining space is packed with dry turmeric leaves and the mouth of the vessel covered with a piece of jute hessian material and sealed with mud plaster. The vessel is placed over a slow fire for about three hours and then allowed to cool. Following this boiling process the rhizomes are removed from the vessel and spread in the sun to dry for five to seven days.

The process of preparing the spice is completed by polishing the dried rhizomes. This is accomplished by rubbing the rhizomes by hand in a serrated earthen vessel or by rotating them for about ten minutes in a cylindrical metal container fitted with handles at either end and mounted horizontally. The product is then ready for market.

It takes about five pounds of fresh rhizomes to produce one pound of cured turmeric.

The quality, appearance, and color of whole turmeric varies according to its source. Ground turmeric of good quality is orange-yellow in color and has a characteristic pepper-like odor and a slightly aromatic, somewhat bitter taste.

Turmeric is available whole or ground. It is used to flavor meat and egg dishes and to add flavor and color to pickles, relishes and prepared mustard. It is an indispensable constituent of curry powder.

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SPICES

Volume II

Morphology · Histology · Chemistry

by

John W. Parry

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Dedicated to my wife
MARY PARRY

PREFACE TO THE SECOND EDITION

The publication of a new edition of this book has afforded an opportunity to add chapters on chervil and tarragon, two herbs that have enjoyed a favored place in European kitchens since ancient Greek and Roman times and that have found increased consumer demand in America in recent years.

It has also afforded an opportunity to add recent information on the composition of the essential oils of the spices as reported in *Chemical Abstracts* of the American Chemical Society and in other scientific journals.

Since almost all of the demand for sweet basil is now met by American growers, the chapter and line drawings of this herb have been revised to cover the domestically cultivated product.

Other additional information has been incorporated into the text, and the glossary has been considerably expanded.

The author would like to take this opportunity to extend his thanks to Sr. Miguel Pascual Giménez, Ingeniero Director, Instituto Nacional de Investigaciones Agronómicas, Ministerio de Agricultura, Murcia, Spain, for information on Spanish paprika; to M. André Darbonne, Syndicat National des Producteurs, Ramasseurs & Collecteurs de Plantes Médicinales, Aromatiques et Industrielles, Milly-La-Forêt, France, for information on chervil and tarragon; to Mr. F. Caligari, Spice Islands Company, California, for his letter on chervil; to Mr. A. W. Pastor, San Jacinto Spice Ranch, Inc., Inglewood, California, for information on the production of sweet basil and tarragon, and for the samples of whole dried leaves of these herbs which he so kindly sent me; and to Mr. Marshall W. Neale, The American Spice Trade Association, New York, for statistical and other information, and for his assistance in obtaining the above samples.

John W. Parry

PREFACE TO THE FIRST EDITION

This work is intended as a short reference book on the structure and chemical composition of spices; to provide helpful information for those whose responsibility it is to examine samples of spices with the microscope; to provide a guide to the microscopy of spices for students of food analysis; to interest students of plant histology and others willing to make a reasonable expenditure of time and study in the structure of spices; to provide information on the structure and chemical composition of spices for the use of all those engaged in, or associated with, the production, manufacture, and distribution of spices; and to convey to the general reader some idea of the external form, the complex but interesting internal structure, and the chemistry of spices.

Part 1 is in no sense an exhaustive enquiry into the anatomy of the parts of plants used as spices, but an attempt to describe as clearly and simply as possible the most important features of the external form and internal structure of the various spices.

Part 2 deals with the chemical composition of spices. The basic chemical composition of spices is much like that of many other plants. However, their volatile oils, oleoresins, pigments, glucosides, and, in some, fixed oils, are chemical compounds of special interest. It is these that make the spices so desirable as food-flavoring agents. These substances have been a matter for investigation by a great number of people over a very long period of time, and are still the subject of enquiry by many capable chemists. Much is known, and much is yet to be learned, about the complex organic chemical compounds contained within the spices. No attempt has been made to discuss the chemistry of the numerous complex chemical compounds involved. Such information can be found in larger reference books, abstracts, and papers.

Part 3 consists of photomicrographs of the spices.

For information on the production of spices the author expresses his gratitude to the Director of Agriculture, Kuala Lampur, Malaya Union; Director of Agriculture, Department of Agriculture, Peradeniya, Ceylon; Director of Commerce, Department of Commerce, Ceylon; Director of Agriculture, Department of Agriculture, Chepauk, Madras, India; Director of Agriculture, Department of Agriculture, Zanzibar, East Africa; Director of Agriculture, Department of Agriculture, Sierra Leone, Africa; Director General, Ministério da Economia, Lisbon, Portugal; Grenada Co-operative Nutmeg Association, Grenada, British West Indies; to Mrs. Ezra Winter, House of Herbs Inc., Salisbury, Connecticut, for samples of peppermint and spearmint; and to Mr. Marshall W. Neale, Director of Information, American Spice Trade Association, New York, for his assistance in obtaining these samples.

John W. Parry

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Part 1

MORPHOLOGY AND HISTOLOGY

INTRODUCTION

Morphology

Morphology is the study of external organic form. In this work, it is the study of the external form of the parts of plants employed to give flavor, relish, and piquancy to foods and found as such in the products of the spice merchant.

It must be kept in mind that spices are *dried* products. The size, shape, color, and general appearance of any one of them will vary to some extent from similar properties in their fresh, living counterparts. Should any descriptive term not be understood it will be found explained in the glossary.

Histology

By histology is meant here the microscopic structure or anatomy of the spices and a study of the cells and tissues of the parts of plants used as spices.

Such a study involves the use of a microscope and other equipment. The microscope is an important, indispensable item. Many fine types are manufactured today. One may buy a very high quality microscope equipped with an incorporated light source, aplanatic condenser, mechanical stage, apochromatic objectives, quadruple nosepiece, compensating oculars, and other advanced features.

However, such an elaborate and expensive instrument is not required for our purpose. An inexpensive microscope equipped with coarse and fine adjustment, a ×10 ocular, two objectives, ×10 and ×25, and substage condenser, will do most of the work. A little more money will buy a very serviceable microscope equipped with a regular Huygenian ×10 ocular, a revolving triple nosepiece, three achromatic objectives, coarse and fine adjustment, a revolving stage, and an Abbe condenser, which will give excellent results. The three objectives recommended are ×10, ×25, and ×50. Very high power is not required in a study of the tissues and cells of plants.

For cutting sections a microtome is a very efficient precision instrument, but satisfactory sections can be cut with a flat-sided razor-type knife obtainable from any laboratory supply house at small expense, or with a safety razor blade. The safety razor blade is a very useful instrument, especially in obtaining sections of very small fruits or seeds.

Inexpensive polarizing apparatus can be easily and quickly made by cutting two discs from a small sheet of Polaroid, one large enough to fit in the filter ring below the substage condenser, or to be otherwise mounted in that position, to act as the polarizer; and one small enough to lie on top of the ocular, to act as the analyzer. The disc to be used as the analyzer can be fitted into a bored cap made from the end of a small, cylindrical paper or plastic box of suitable diameter. This is a useful arrangement and permits the easy rotation of the analyzer. Polarized light is a helpful aid in the study and identification of starch, crystals, and lignified tissues.

Measurements can be made with an ocular micrometer. Such a micrometer consists of a glass disc on which is engraved a scale of divisions, usually 50, without value. The disc is laid upon the diaphragm within the ocular, scale side downward. To give a value to the divisions of the ocular micrometer they must be calibrated with those of a stage micrometer. The scale of the stage micrometer is engraved upon a glass slide and usually consists of 100 divisions, each with a value of 0.01 mm. or 10 microns. The stage micrometer is brought into focus and the number of divisions covered by the entire ocular micrometer scale is noted, multiplied by 10 and divided by 50. This will give the value in microns of each division of the ocular micrometer. For example, let us say that the entire micrometer scale covers 69 divisions of the stage micrometer scale, then 69 × 0.01 mm equals 0.69 mm, and 0.69 mm × 1000 equals 690 microns (or simply 69 × 10 equals 690), and 690 microns divided by 50 equals 13.8 microns to each division of the ocular micrometer scale.

Calibrations must be made for each combination of ocular and objective. The higher the power the less the number of microns to each division of the ocular micrometer scale. Glass ocular and stage micrometers are inexpensive and obtainable from any laboratory supply house.

Dissecting needles can be obtained from a laboratory supply house, or they can be made by attaching ordinary sewing or darning needles to wooden handles. A bent needle can be obtained by heating a sewing or darning needle in a flame until it is red hot, bending, reheating, and tempering in cold water. Dissecting needles are useful for pulling apart fibrous tissues.

A pair of fine-pointed forceps will be required, and a pair of small scissors should be at hand.

A number of glass slides and cover glasses will be required; square cover glasses are recommended. Water can be contained in any small table glass. Medicine droppers are excellent for conveying liquids to slides.

A spice may be soaked in water contained in a small glass, but if it requires boiling then a pyrex beaker must be used. A beaker of pyrex glass may be safely employed over a bunsen burner, on a hot plate, or on a kitchen stove; a useful size is 50 ml.

A supply of household bleach, concentrated sulfuric acid, iodine-potassium iodide solution, and chlor-zinc-iodine will suffice for reagents and stains. If desired, a supply of phloroglucinol and hydrochloric acid may be included. Phloroglucinol ((5% in 90% alcohol) followed by hydrochloric acid diluted with an equal volume of water, is a useful stain for confirming the presence of lignified tissue. Lignified cell walls stain red or reddish-violet with phloroglucinol.

A hand magnifying glass is useful, or better still, the type of magnifier used by watchmakers. This is attached to a narrow, spring-like metal band which encircles the head and holds the lens in front of the eye. With its use both hands are free to section or dissect the spice.

It is the ground spice that is usually examined under the microscope. But before the analyst can identify a spice under examination he must be familiar with the tissues characteristic of that spice. A study of sections of whole spices will enable the analyst to identify the fragments of tissues of ground spices seen in the microscope field. Failing the knowledge obtained from such a study he must have reference to this or other texts on the microscopical structure of spices.

It is nearly always necessary to soak the spice in water to soften it sufficiently for sectioning. Some spices are very hard and must be softened by boiling in water; a little sodium hydroxide or a pinch or two of washing soda (sodium carbonate) added to the water will assist the process.

After the spice is soft enough to section, it should be held firmly between the forefinger and thumb, or held firmly against the surface of a glass slide laid upon the work table, and the desired section cut with a cutting knife or razor blade. If the spice cannot be held firmly with the hand it may be embedded in paraffin wax. This will provide support and leave no foreign material clinging to the section. If the wax does not fall away cleanly it can be removed by immersing the section in hot water. A transverse (cross) section is obtained by cutting across the longitudinal axis, a longitudinal section by cutting through the longitudinal axis, and a tangential section by cutting parallel to the longitudinal axis but not through the center of the spice.

The section is placed in a drop or two of water on a glass slide and covered with a cover glass. If the edge of the cover glass is brought into contact with the water and the glass lowered gently with the aid of a dissecting needle, no air bubbles will be left between the cover glass and the slide. The section may then be examined with the low power of the microscope. Higher powers can be used to permit a study of the cells, cell inclusions, and tissues in greater detail.

Seen at this time, the cells will be partly expanded as a result of the soaking process, and the cell inclusions will be visible. The pigments may be decolored and the cells further expanded by treatment with dilute household bleach. Sections may be bleached on the slide by drawing the bleaching solution under the cover glass. This is done by applying a piece of absorbent paper tissue or blotting paper to one edge of the cover glass and the bleaching reagent to the other. The water is drawn off and replaced by the bleach. Many bubbles arise in the process of bleaching but most of these are removed when the bleach is replaced with water after the section is decolored. The few bubbles remaining will not interfere with the study of the subject. If it is now desired to stain the section, chlor-zinc-iodine is drawn under the cover glass. Cuticle, cutinized, and lignified cell walls will stain yellow; cellulose walls, blue; starch, dark blue; proteins, brown. Regarding lignified cells it should be said that if sections are left too long in the bleaching solution, all or part of the lignin may be dissolved and the walls will give a blue color with chlor-zinc-iodine (cellulose).

Unbleached sections may be stained by treatment with iodine-potassium iodide solution followed by chlor-zinc-iodine. Color reactions will be similar to those given above except for such interference as pigments present. The presence of lignified tissues may be confirmed by staining another section with phloroglucinol.

Iodine-potassium iodide solution stains starch dark blue; aleurone, yellow to brown. It should be remembered that boiling, and solutions of alkali hydroxides, cause swelling and destruction of starch granules. For a microscopic study of starch the spice should be softened in cold or warm water, sectioned, and examined in water mount without further treatment. The presence of starch can be confirmed by drawing iodine-potassium iodide solution under the cover glass.

Concentrated sulfuric acid dissolves cellulose quickly; chars and blackens lignin, but does not alter cuticle or cutinized cell walls. Suberized cell walls are also unaffected by concentrated sulphuric acid.

Ground spices may be mounted directly in a drop or two of water placed on a glass slide, overlaid with a cover glass, and examined under the microscope. Ground spices are usually of requisite fineness for direct examination but if the fragments appear too coarse or too densely packed they may be rubbed out by applying gentle pressure to the cover glass and making a to-and-fro motion. A pencil with a clean eraser on the end is useful for this purpose. There is enough friction between eraser and glass to permit the movement of the cover glass to-and-fro without messing it up as occurs when using the finger, necessitating the removal, cleaning, and replacing of the cover glass. Bleaching and staining, if required, may be carried out in the manner described above.

Tissues will now be discussed. The simple tissues are parenchyma, collenchyma, and sclerenchyma. Parenchyma tissue is the most common and consists of cells with thin or moderately thick cellulose walls, with or without intercellular spaces. Parenchyma cells in living plants are approximately isodiametric, but in the dried spices they are nearly always collapsed and compressed, and even when expanded with the aid of reagents may fall short of their original shape, frequently appearing irregular or elongated. Parenchyma cells occur in all of the spices; they are abundant in the mesocarp of fruits, the mesophyll of leaves, and in cortex tissue. Epidermal cells are modified parenchmya cells, frequently polygonal in shape in surface view, rectangular or oblong-rectangular in cross section.

Collenchyma is a supporting tissue, and consists of cells with irregularly thickened walls or walls thickened at the corners of the cells. The walls are composed of cellulose and are highly refractive, appearing bright and shiny; they stain blue with clor-zinc-iodine. Collenchyma occurs in the pedicels of the spice fruits of the Umbelliferae except cumin; in the leaves, petioles, and stems of the spice herbs of the Labiatae; and in some other spices.

Sclerenchyma is a supporting, strengthening and protective tissue consisting of cells with thick, lignified walls. Sclerenchyma occurs in many forms. The chief kinds of sclerenchyma cells are stone cells and sclerenchyma fibers. Stone cells vary greatly in size and shape, but are not much longer than broad and have very thick, pitted walls. Sclerenchyma fibers are elongated cells, usually with pointed or tapering ends, and with thick, usually pitted, walls. Sclerenchyma is present to some extent in nearly all of the spices.

Complex tissues are phloem and xylem. They form the conducting or vascular tissue of the plant. In the widest sense, phloem includes sieve tubes, companion cells, parenchyma, and fibers. The parenchyma is known as phloem parenchyma, and the fibers as phloem or bast fibers. Xylem includes vessels, parenchyma, and fibers. The parenchyma is known as xylem parenchyma, and the fibers as xylem or wood fibers. Fibers are not always present in phloem and xylem. In the text, the term *vascular bundle* is used to indicate a bundle of phloem and xylem without fibers, and the older term *fibrovascular bundle* to indicate a bundle of phloem and xylem with fibers. A vessel is a tubelike series of cells characterized by lignified thickening deposited in various ways on the inside of the walls. The degree of lignification varies. Vessels are known as annular, spiral, scalariform, reticulated, or pitted. In annular vessels the thickening is laid down in rings; in spiral vessels in the form of spiral coils; in scalariform in transverse bars; in reticulated vessels in the form of an irregular network; in pitted vessels the thickening is nearly uniform except for small areas or pits.

The drawings and photomicrographs appearing in the text are by the author. Space does not allow all the descriptive drawings that could be made, nor the inclusion of all the photomicrographs which are on hand, to illustrate the histological structure of the spices, but it is hoped that those that appear in this work will be of assistance to the analyst, investigator, or student, and of interest to the general reader.

Rhizomes, Barks, Floral Parts, Buds, Fruits and Seeds

I. ALLSPICE

Pimenta officinalis Lindl
Family: *Myrtaceae*

[ALLSPICE, PIMENTO, JAMAICA PIMENTO, JAMAICA PEPPER, CLOVE PEPPER]

GENERAL

An evergreen tree, 25 to 30 feet in height; trunk erect, bark gray; much branched; round-topped; foliage dense. Leaves opposite, oval-oblong to elliptical, entire, glandular-punctate on lower surface; 4 to 6 inches in length; deep green, lustrous. Flowers borne on racemose cymes, small, white to greenish-white, sepals 4, petals 4, stamens numerous; ovary 2-loculed, inferior.

Allspice fruits are harvested when mature but still green. The fruits are dried in the sun; their color changes during drying to dark reddish-brown.

Allspice trees bear fruits in about 7 years and are productive for about a further 12 years.

MORPHOLOGY

A dried, dark reddish-brown, hard berry with a rough surface caused by numerous protuberant oil cavities underlying the exocarp. Calyx and style remains at the apex, stalk scar at the base or, occasionally, a short stalk or portion of stalk. In shape, nearly globular. In size, from about 4 to 7 mm. Pericarp woody, brittle, and around 1 mm in thickness.

The berry has 2 locules separated by a thin dissepiment or partition. Each locule contains a single, reniform, hard, dark brown seed. The embryo is large, curled, with prominent radicle and small cotyledons.

The aroma is fragrant, clove-like; the taste is clove-like, strongly aromatic, pungent.

The name "allspice" is given to this spice because its flavor is said to resemble a combination of cinnamon, nutmeg and cloves.

HISTOLOGY

Pericarp

This consists of exocarp, mesocarp, and endocarp.

Exocarp. In cross section, consisting of epidermis with stomata and short, thick-walled, unicellular, nonglandular hairs up to about 150 microns in length. These hairs are easily broken off in the preparation of the section and are best studied in surface view.

The cells of the epidermis are small, up to about 10 microns, long axis; tangentially oblong-rectangular or nearly so, and have strongly cutinized outer walls. In surface view the epidermal cells are small, from about 5 to 22 microns, and polygonal in shape.

Mesocarp. Cross section. In the outer mesocarp, near the epidermis, there is an oil zone consisting of numerous cavities in which the essential oil of allspice is secreted. These cavities are oval or round in shape. The oval cavities vary in size to about 210 microns, long axis, and to about 150 microns, short axis. The round cavities vary in size from about 60 to 210 microns in diameter; the majority are from about 150 to 180 microns in diameter.

Scattered throughout the mesocarp are numerous pitted, striated stone cells varying greatly in amount of wall thickening, in size and shape. They occur singly, in small groups, and in masses. Individual cells reach up to about 110 microns, long axis, and in the apex region of the mesocarp to about 150 microns; the latter stone cells have, in general, thinner walls.

Fibrovascular bundles occur in the mesocarp. Seen in longitudinal section the vessels are spiral; the fibers have thick, pitted walls, and vary in width and length. The fibers are not numerous.

The ground tissue of the mesocarp consists of thin-walled parenchyma cells, somewhat compressed, and irregular in shape. Rosette crystals of calcium oxalate are scattered throughout the mesocarp but occur more abundantly near and between the oil cavities.

Groups of stone cells occur in the inner mesocarp. These cells vary in size from about 30 to 60 microns, long axis, and the groups extend to about 1300 microns in length. A few layers of compressed parenchyma cells separate the inner mesocarp stone cells from the endocarp.

Endocarp. The endocarp consists for the most part of a layer of compressed parenchyma tissue. In the apex region, near the locule partition in the area of the calyx remains, the endocarp cells become rectangular in shape, and average about 12 microns square. In surface view, for the most part, the endocarp cells are elongated, narrow, and thin-walled.

Locule Partition

The locule partition or dissepiment consists of parenchyma tissue with a few stone cells and numerous crystals of calcium oxalate; both rosette and prismatic crystals occur. Vascular tissue traverses the parenchyma. A very thin cuticle is present on both surfaces.

Seed

Seed Coat. In cross section, the seed coat consists of compressed parenchyma tissue contained between an outer and inner epidermis except on the outer convex and inner flat sides of the seed where the outer and inner epidermis enclose several layers of cells filled with a rich orange-red, gummy or resinous substance. These cells have been called "port wine" cells by early writers and are frequently referred to as such nowadays. This description might apply, but only approximately so, when the resin cells are clumped together and less penetrable to transmitted light. The resin cells are an important identifying characteristic of ground allspice.

The outer walls of the outer epidermis are strongly cutinized, those of the inner epidermis weakly so. In surface view the cells of both the outer and inner epidermis are elongated, narrow, and have faintly beaded walls. They vary in arrangement, with a tendency to parquetry in places.

Vascular tissue with delicate spiral vessels occurs in the seed coat and is usually seen on the inner side of the resin parenchyma adjoining the inner epidermis.

Embryo. The embryo is curled and consists of a large radicle and two small cotyledons. In cross section, the epidermis consists of small, clear cells covered by a very thin cuticle. Underlying the epidermis there is an oil zone with cavities smaller than, but similar to, those of the pericarp. Rudimentary vascular tissue occurs in the central zone of the embryo; delicate spiral vessels are observed in longitudinal section. The remaining tissue consists of small, isodiametric parenchyma cells containing mostly round but some truncated granules of starch, 4 to 12 microns in diameter, and with central hilum.

Pedicel. An untreated cross section of the pedicel viewed under low power shows the epidermis and cortex tissue dark reddish-brown; phloem tissue and pith dark orange; fibers and xylem obscurely yellow, the fibers masked by the surrounding orange color, and the xylem by light transmitted through the lumen of the radial rows of vessels and accompanying tissues.

For a detailed examination, a section should be decolored and the cells expanded by treatment with bleaching solution. A second section should be so treated and then stained with chlor-zinc-iodine.

In cross section, the pedicel consists of (a) epidermis of small cells with strongly cutinized radial and outer walls; (b) cortex of thick-walled, irregular-shaped cells varying in size to about 67 microns, long axis; intercellular spaces; rosette crystals of calcium oxalate occurring in some cells; and occasional oil cavities, round, oval or elliptical, from about 65 to 85 microns, diameter or long axis; (c) a broken ring of thick-walled pericycle fibers; (d) thick-walled phloem tissue with some cells containing prismatic crystals of calcium oxalate; (e) an unbroken ring of xylem tissue with vessels in radial rows, fibers, parenchyma cells, and xylem ray cells; (f) pith of thick-walled parenchyma cells, some containing rosette crystals of calcium oxalate, and thick-walled fibers singly or in groups.

In surface view, the epidermis consists of rectangular to polygonal (mostly the latter), thick-walled, frequently pitted or beaded cells up to about 25 microns, long axis; numerous hairs, straight or curved, pointed, unicellular, varying in length to about 165 microns. No stomata.

Seen in longitudinal section, the pericycle fibers are long, thick-walled, pitted, with lumen narrow to wide. The pith fibers are shorter than those of the pericycle, pitted, and with narrow lumen. Noteworthy in the phloem tissue are chains of prismatic crystals of calcium oxalate; crystals imperfect, but of tetragonal prism-pyramid, rhombic, and cubic types up to 12 microns, long axis. The xylem consists of numerous spiral vessels, fibers, and thick-walled, pitted parenchyma cells.

Ground Allspice

The most important identifying characteristics of ground allspice are (a) the so-called port wine cells of the seed coat, the resin cells; (b) the stone cells, which are numerous; (c) fragments of the pericarp with oil cavities; (d) fragments of the exocarp, and short unicellular hairs; (e) starch; and (f) fragments of the embryo.

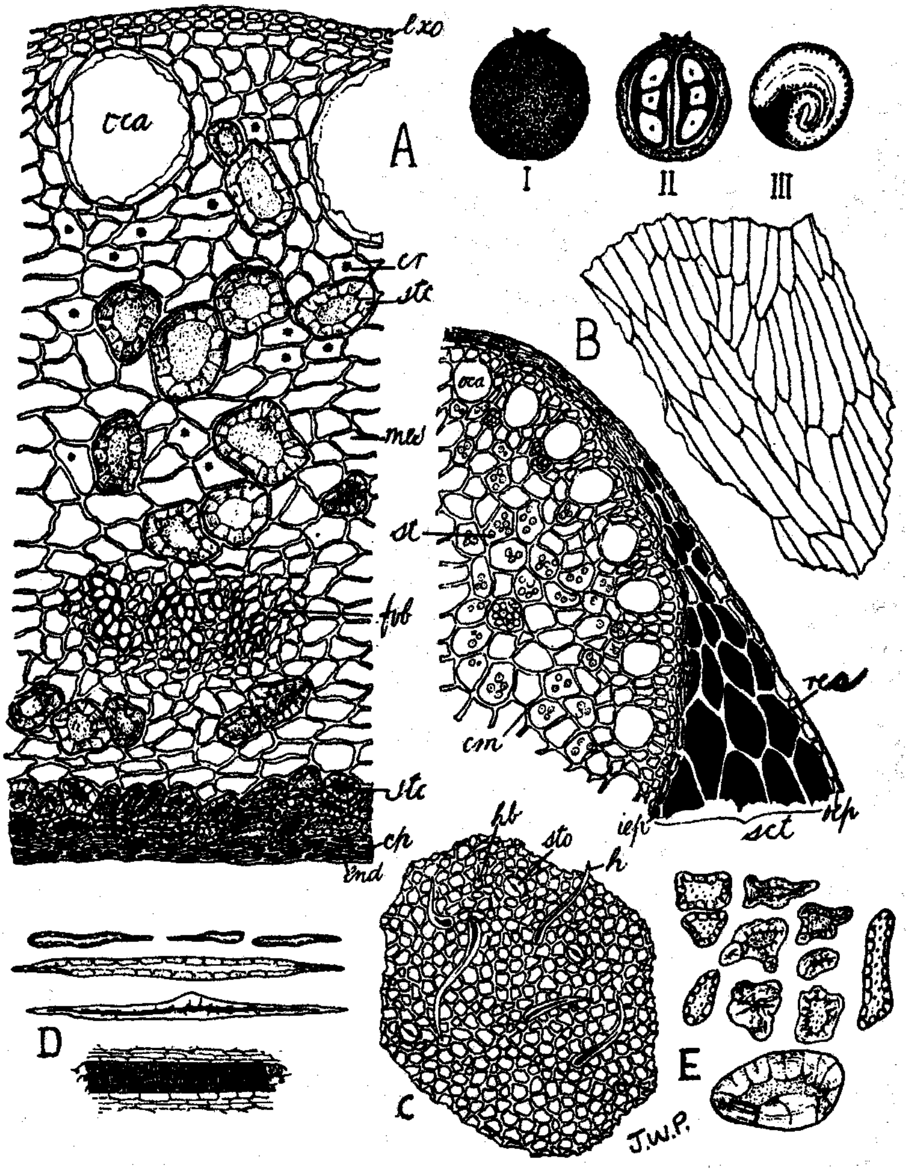

Fig. 1. ALLSPICE. I—Fruit. II—Fruit, longitudinal section. III—Seed, cross section (A) Cross section of pericarp. (B) Cross section of a portion of seed (left): surface view of epidermis of seed coat (right). (C) Exocarp, surface view. (D) Fibers and spiral vessels. E, Stone cells.

cp, compressed cells; cr, crystals; em, embryo; end, endocarp; exo, exocarp; fvb, fibrovascular bundle; h, hair; hb, hair base; iep, inner epidermis; mes, mesocarp; oca, oil cavity; oep, outer epidermis; res, resin cells; sct, seed coat; st, starch; stc, stone cells; sto, stoma.

II. CAPSICUMS

Capsicum

Family: *Solanaceae*

GENERAL

Herbaceous or semiwoody plants, annual or perennial, 1½ to 4 feet or more in height, of many varieties and diverse forms.

Stems branched and more or less angular or channelled.

Leaves alternate, entire, accuminate, petiolate, dark green on the upper surface, paler on the lower.

Flowers axillary, solitary or in fascicles of 2's or 3's; corolla gamopetalous and generally with 5 to 6, sometimes 7, segments, rotate; stamens generally 5 to 6, adnate, and arising from the corolla; ovary superior.

Calyx saucer to cup-shaped, persistant, normally with six short teeth and a thick peduncle.

Fruit a podlike berry, generally with 2 to 4 locules united in the upper part and divided below; varying in shape and size; seeds small, discoid.

Capsicum Spices

Cayenne pepper, red pepper, chilli powder, and paprika are all prepared from dried, ripe fruits of the genus *Capsicum*.

Dried capsicum red peppers vary considerably in size and flavor. The small, conical, acrid peppers are commonly known as chillies; they are used whole for pickling purposes, or they are ground to make Cayenne pepper. Red pepper may be Cayenne pepper, or a pungent pepper made by grinding larger fruits such as the Long Red Cayenne. Chilli powder is prepared from selected, mild or pungent Capsicum fruits, depending upon whether a mild or "hot" product is required.

Cayenne pepper is ascribed to *Capsicum frutescens*, *Capsicum boccatum*, or some other small-fruited species of *capsicum* and paprika to *Capsicum annuum* in government standards, but it should be pointed out that it is the opinion of at least one notable systematic botanist,—namely, L. H. Bailey,—that there is only one species of the genus, the shrubby *C. frutescens*, and that all other horticultural kinds are but forms of this species, including the annual kinds which, he says, develop in a short season and do not become woody before being killed by frost.

MORPHOLOGY

Capsicum fruits employed in the spice trade vary in size from about 6 mm to 15 cm in length. The dried fruits are laterally compressed, conical, base blunt, apex sharp, pointed; calyx and peduncle usually attached to the larger fruits, and sometimes to the smaller; color varying from a murky brownish-red to a rich deep-red.

The pericarp is thin, lustrous; smooth in some varieties, wrinkled in others; containing 2 to 4 locules with central placentae united at the base, and toward the apex parietal placentae marked by longitudinal ridges.

The seeds are numerous, attached to the central placentae or free; discoid, nearly circular, flat with thickened edge; prominent, pointed micropyle adjoining the hilum; hard, smooth, yellow; about 2 to 5 mm in size; and containing a curved embryo embedded in the endosperm.

Odor characteristic, sternutatory, but not unpleasant; taste mildly to intensely pungent.

The more important pungent capsicum fruits are:

African Chillies (Mombasa, Congo, Zanzibar). Length about 9 to 15 mm; murky brownish-red; wrinkled, lustrous, very bright; very acrid. Nigerian chillies: Length 12 to 31 mm; bright red; wrinkled, lustrous, very bright; acrid.

Mexican Chillies (Chiltepin, also known as Chilepiquine, Chili piquin, Chile petine). Length 6 to 14 mm; orange-red; smooth, lustrous, bright; very acrid.

Japanese Chillies (Honka, known as Hontakas). Length 25 to 50 mm; orange-red to dark red; compressed, somewhat wrinkled, lustrous, bright; very pungent.

U. S. A. Domestic Sports (Louisiana sport pepper). Length 25 to 57 mm; orange-red to deep-red; smooth, lustrous, bright; very pungent.

An important large fruit is the **Mexican Chilli Pod (Chile Ancho,** var. *accuminatum*). Large fruits, from about 9 to 11 cm in length, and from about 6 to 7 cm at the widest part of the fruit when measured in the dried, compressed state. The pericarp is wrinkled, lustrous, and maroon in color. The calyx is of the flat or saucer type and adheres firmly to the fruit; the peduncle is curved, stout, and from 3.8 to 5 cm long.

Mexican chilli pods are moderately pungent. They are employed in the making of Mexican chilli powder.

An examination of the tissues of Mombasa, Nigerian, Congo (Africa); Piquin (Mexico); Hontaka (Japan); and Louisiana (America) chillies show that these varieties are almost entirely similar in structure. The principal differences lie in the existence of a hypodermis of 1 to 3 layers of cells in Louisiana Sport chillies, an hypodermis of 1 layer of cells in Hontaka chillies, and no hypodermis in Piquin and African chillies; in the thickness and beading of the cell walls of the epidermis as seen in surface view; and, to a limited extent, in the size of some cells.

Paprika is the finely ground product of mature, dried, sound and clean fruits or peppers of *Capsicum annuum* L. A number of types of paprika are manufactured but they can be included in three main categories—namely, Sweet, Semisweet, and Pungent.

There are also various qualities of each type. First quality paprika is prepared from the pericarp of first quality peppers. No peduncles, calices, placenta tissue or seeds are included in the product. Second quality paprika is prepared from the pericarp of good quality peppers and the product may include a small percentage of seeds and adhering placenta tissue but no peduncles or calices. Lower qualities are prepared from peppers of lower quality and include pericarps, placentae, seeds and, in some low grade paprikas, peduncles and calices. For the manufacture of Sweet and Semisweet paprikas, where included, the seeds and adhering placenta tissue are macerated and washed in water to deprive them of part of their pungent content, *capsaicin*.

The color of first quality paprika is a rich red, that of second quality a less intense red. Lower quality paprikas vary in color from brick-red to brownish-red or brownish-yellow.

Paprika is manufactured in a number of countries including the United States of America. In recent times, of the paprika imported by the United States the greatest quantity came from Spain—5,314,497 lb in 1967.

In Spain, three types of paprika are manufactured—namely, "Dulce" or Sweet, "Agridulce" or Semisweet, and "Picante" or Pungent. The last mentioned paprika is prepared from the fruits of *C. annuum* variety *longum*. It is not exported to the United States of America. Each type is marketed in three qualities: Extra, Select, and Common. These paprikas are prepared as above. A limit of 10% is imposed upon seed content in the Select quality and 30% in the Common.

Four varieties of capsicum peppers are employed in the manufacture of the sweet paprikas. As named in Spain, they are Ramillete, Tres Cascos, Bola, and Albar. The fresh fruit of the first variety is globose in shape but somewhat flattish at the base and apex. It has a thick, fleshy pericarp, four locules, and many seeds. The fresh fruit of the second variety is globose but distinctly flat at the apex. It has a less fleshy pericarp, three locules, and numerous seeds. The fresh fruit of the third variety is truncated-conical in shape and is somewhat smaller than the previous varieties. It has a pericarp about half as fleshy as that of the first variety, three locules, and many seeds. The fresh fruit of the fourth variety is globose but flat at the base and apex. The calyx has six lobes as against five in the other varieties. The pericarp is about as fleshy as that of the second variety. It has three large locules, a small, ruddy placenta, and many seeds.

The following table shows the weight of the parts of the fruit at the termination of the drying process, obtained from 100 kilograms of fresh fruit:

		Ramillete	*Tres Cascos*	*Bola*	*Albar*
Pericarps	kg	11.84	10.54	11.30	12.04
Seeds	kg	10.00	9.00	8.54	8.83
Placentae	kg	1.44	1.44	1.52	1.33
Peduncles and calices	kg	1.40	1.54	1.50	1.16
		24.68	22.52	22.86	23.36
Less:					
Peduncles and calices		1.40	1.54	1.50	1.16
Weight of dried pods	kg	23.28	20.98	21.36	22.20
Percentage of pericarps to pods		50.86	50.24	52.90	54.23
seeds " "		42.95	42.90	39.98	39.77
placentae " "		6.19	6.86	7.12	6.00
		100.00	100.00	100.00	100.00

It should not be concluded that a high yield of pericarps, as the Albar variety shows, will necessarily produce a good quality paprika. Color and smoothness are essential properties of paprika. To obtain these and other elements which characterize good paprika advantage must be taken of the particular qualities each variety of peppers can contribute to the product.*

HISTOLOGY

Pericarp

Cross section unless otherwise indicated. The tissues of the pericarp consist of the following:

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* D. Ignacio Vivancos Guerao, *Estudio de las Variedades de Pimentos Pimentoneros*, I.N.I.A., Ministerio de Agricultura, Murcia (Spain), n.d.

Cuticle. The cuticle varies in thickness from about 18 to 24 microns in the different varieties of capsicum fruits. In some varieties the cuticle almost surrounds each cell of the epidermis, penetrating down between the cells. In Paprika the cuticle shows distinct grooves, many 12 to 15 microns deep; in surface view these grooves are numerous and of various lengths, many from about 45 to 100 microns long.

Epidermis. The epidermal cells of all varieties tend to a more or less rectangular shape, and are arranged in fairly regular order. There are areas where the cells are of irregular order, and with shapes varying from nearly rectangular to triangular or polygonal, but these cannot be held to be characteristic of any particular variety. The epidermal cells of Congo chillies, measured between the walls, are from 20 to 45 microns, long axis; of Hontaka chillies, from 30 to 45 microns; of Nigerian, Mombasa, Piquin, and Louisiana Sport chillies, from 30 to 60 microns; of the large-fruited Ancho chillies, from 30 to 60 microns; and of Paprika, from 30 to 60 microns. In every variety there are cells that will exceed these measurements but they are exceptional and not typical. The length of the short axis varies somewhat, but in most cases the cells are in the neighborhood of 20 microns.

Seen in surface view, the epidermal cell walls of Piquin, Nigerian and Mombasa chillies are 5 to 6 microns wide; of Congo chillies, 8 microns; of Louisiana Sport chillies, 9 to 12 microns; of Hontaka chillies, 24 to 27 microns; of Ancho chillies, 9 to 12 microns; and of Paprika, 9 to 10 microns. Pitting occurs in the walls of the epidermal cells of these fruits, but some variation exists in the style and extent of pitting in the different varieties. In some varieties the pitting is clearly observable with low power in others only with intermediate, or high, powers. For example, the epidermal cell walls of Congo and Mombasa chillies are similarly pitted, but the pitting of the Mombasa walls becomes apparent at ×250 and higher power, whereas that of the Congo walls is distinct at ×100 power. The pitting does not extend to the middle lamella in Piquin and Hontaka chillies. In Louisiana Sport chillies the pitting frequently extends to the middle lamella and is distinct at ×100 power. Pitting is also a characteristic of the epidermal cell walls of the larger fruits.

The color of the epidermis, observed in surface view, varies from a weak yellow to orange, but this is not a very helpful aid to the recognition of the different varieties of capsicum fruits. The color is affected by exposure to light, and deteriorates to some extent as the chillies or powders age.

Hypodermis. The hypodermis consists of tangentially oval cells with thick walls. In mature Hontaka chillies there is usually a single layer of these cells, occasionally more, varying in size up to about 66 microns, long axis. In Louisiana Sport chillies the hypodermis consists of 1 to 3 layers of cells, up to about

45 microns. In the large-fruited capsicums the hypodermis consists of several layers of cells varying in size from about 30 to 60 microns, long axis, with walls 12 to 15 microns thick.

Mesocarp. The mesocarp consists of parenchyma cells that have been compressed into a tangentially oblong-oval shape. These cells vary greatly in size, extending in the small fruits to 180 microns over the long axis, and in the large fruits to 700 microns. The cell contents consist of chloroplasts and oil; the oil globules are numerous and vary in size.

When brought into contact with concentrated sulfuric acid drawn under the cover glass, the oil drops turn an indigo blue in color.

Vascular Bundles. In all capsicum fruits the vascular bundles of the pericarp consist of xylem tissue with spiral vessels, and phloem tissue. There are no fibers in the pericarp. The spiral vessels are from 9 to 12 microns in diameter for the most part but some reach 21 microns. Vessels of the latter diameter are not abundant. The vascular bundles are situated in the inner region of the mesocarp.

Giant Cells. The so-called "giant cells" are situated between the mesocarp and the thick endocarp, and are bounded on their radial walls by a triangular or wedge-shaped group of parenchyma cells. The giant cells are responsible for the numerous blisters seen on the inner surface of the pericarp. They are characteristic of all capsicum fruits.

Endocarp. The endocarp bounding the giant cells consists of somewhat rectangular or oblong-rectangular cells with thick, lignified, pitted walls. Adjoining the mesocarp tissue between the giant cells the endocarp consists of cells similar in shape to those of the thick endocarp but with thin, cellulose walls. The lignified walls are from about 9 to 12 microns in width; the cellulose walls about 4 or 5 microns. In surface view, both types of endocarp cells are irregular to polygonal in shape, and vary from about 15 to 90 microns, long axis.

Dissepiment

The endocarp continues on to the dissepiment, modifying and passing into epidermis tissue. A thin cuticle covers each epidermis. Fibrovascular tissue occurs in the parenchymatous central zone; spiral vessels are numerous, phloem and xylem fibers are present.

Calyx

In cross section, the calyx consists of the following tissues:

Outer Epidermis. In the small-fruited capsicums the cells of the outer epidermis are mostly rectangular-oblong in shape, fairly regular, with beaded cell walls. They vary in size from about 20 to 75 microns, long axis, and are about 15 microns, short axis. Stomata are numerous. Occasional 1- and 2-celled hairs from about 45 to 90 microns long are present. A thin cuticle covers the epidermis.

In the large-fruited capsicums the cells of the outer epidermis are mostly rectangular-oblong in shape, some are triangular or nearly so, others are polygonal. They vary in size from about 30 to 90 microns, long axis, and are about 24 microns, short axis. The cell walls are beaded and about 6 microns thick. Stomata are numerous, and there are no hairs. A cuticle is present.

Outer Hypodermis. An hypodermis exists in the calyx of both small and large fruits and consists of partially collapsed cells varying in size from about 20 to 30 microns, long axis, in the small fruits, and from about 20 to 200 microns in the large. The cell walls are partially lignified.

Mesophyll. In the calyx of both small and large fruits the mesophyll consists of large, collapsed parenchyma cells with contorted walls. Fibrovascular bundles occur in this tissue.

Inner Hypodermis. Similar to the outer hypodermis, but the cells are smaller.

Inner Epidermis. With the difference that the cell walls tend to be sinuous, the cells of the inner epidermis are similar to those of the outer; in the large fruits these cells are up to about 105 microns, long axis. Stomata are not numerous. In both small and large fruits numerous multicellular, capitate hairs arise from the inner epidermis. These hairs are about 90 microns long; the basal cell is about 30 microns long and about 25 microns in diameter; the head varies from about 30 to 36 microns in diameter. The basal cell is colorless, the remaining cells have yellow to yellowish-orange contents.

Stone Cells

In the region of fusion of calyx and peduncle there are numerous sclerenchymatous cells with thin, pitted walls. The shape of these cells varies considerably; in size they vary from about 65 to 120 microns, long axis.

Peduncle

In cross section the peduncle consists of the following tissues:

Epidermis. In the small-fruited capsicums the cells of the epidermis are mostly rectangular-oblong, or nearly so, in shape; they vary from about 20 to 90 microns, long axis, and from about 15 to 20 microns, short axis. The cell walls are beaded, and are about 4 to 5 microns thick. Stomata are fairly numerous. A thin cuticle is present.

In the large-fruited capsicums the epidermal cells vary in shape; the greater number are rectangular-square or rectagular-oblong, but some tend to the triangular, and some are polygonal. They vary in size from about 20 to 90 microns, long axis, and are from about 20 to 60 microns, short axis; the cell walls are beaded, and from about 4 to 6 microns thick. Stomata are not numerous. A thin cuticle is present.

Hypodermis. In small-fruited capsicums the hypodermis may not exceed a single layer of cells. These cells vary in size from about 12 to 21 microns, long axis, and have thick, regular walls. In the large fruits, the hypodermis may consist of 3 layers of cells, varying in size from about 20 to 75 microns, long axis, and with thick, somewhat contorted walls. In both types of fruit the hypodermal cells are partially lignified and refract polarized light.

Cortex. The parenchyma cells of the cortex appear loose and collapsed; there is no regularity to the shape of the cells, and the walls are much contorted. They vary in size: in the small fruits from about 20 to 60 microns, long axis, and in the large fruits from about 20 to 75 microns with occasional cells reaching as much as 450 microns, long axis.

Fibrovascular Tissue. Phloem fibers occur in close proximity to the outer side of the external phloem tissue. They occur singly, in pairs, and in small groups separated by parenchyma tissue. In the small fruits they vary in diameter from about 9 to 21 microns, with walls from about 3 to 6 microns in thickness; and in the large fruits from about 9 to 84 microns in diameter, with walls from about 4 to 15 microns in thickness.

External Phloem. In both small and large fruits the external phloem of the peduncle consists of a continuous ring of closely arranged cells.

Xylem. In both small and large fruits the xylem forms a continuous ring of tissue broken only by the radial xylem rays. In the small fruits the xylem fibers and the vessels are around 9 or 10 microns in diameter; in the large fruits from about 9 to 30 microns. Spiral, reticulate, and scalariform vessels occur in both small and large fruits; the fibers are pitted.

Internal Phloem. In the small fruits only a few fragments of disintegrated phloem cells remain. In the large fruits the internal phloem consists of a continuous ring of small, closely arranged cells.

Pith. Pith tissue is seen only in the peduncle of large fruits, and then not in its entirety. It is more abundant toward the calyx; away from the calyx the pith is almost entirely absent and the peduncle appears hollow. The pith cells are collapsed, and the cell walls are contorted; they vary in size from about 60 to 160 microns, long axis.

Seed

The seed of all types of capsicum fruits is flat, discoid, and consists of a strong, tough seed coat covered with a thin cuticle; an abundant endosperm, and an embryo with long cotyledons.

Seed Coat. In cross section, this consists of (a) an outer epidermis of large cells with thick, sclerenchymatous basal and radial walls, and a cellulose outer wall thinly lignified on the inner side. The size of the cells and the extent of the thickening is very much greater on the edge or ridge of the seed than on the flat sides (see also under "Ground Capsicum"); (b) a few layers of parenchyma cells, usually collapsed and disintegrated, but sometimes up to 3 layers of sound cells; (c) an inner epidermis of small, regularly arranged, thin-walled cells.

Endosperm. This consists of polygonal cells varying in size from about 10 to 55 microns, long axis, with colorless walls from about 3 to 6 microns in thickness. The cell contents are aleurone grains and globules of fixed oil.

Embryo. This lies coiled and embedded in the endosperm. It is fully developed and consists of radicle and two cotyledons.

Ground Capsicum

Fragments of all the small-fruit tissues described above may appear in the microscope field of cayenne pepper. In some samples, tissues of the calyx and peduncle may be absent; calyx and peduncle remains are common on Hontaka chillies, not uncommon on Mombasa chillies, but of rare occurrence on Nigerian, Congo and Piquin chillies.

In samples of certain high-grade paprikas only large-fruit pericarp tissues will be seen; in other grades these and seed tissues, and in still others, all the tissues of large fruits described above.

An outstanding identifying characteristic of ground capsicum is the sclerenchymatous endocarp; of cayenne pepper and most paprikas, also the thick-walled cells of the outer epidermis of the seed coat. Seen in surface view, the ridge cells of the outer epidermis are greatly contorted, small, and have very thick, sinuous walls. The cells of the flat sides are equally contorted, but very large; the cell walls are sinuous, and have much less thickening than those of the ridge cells; the thickening, in places, is almost entirely on one side of the middle lamella. The structure and sculpturing of the walls of these cells exhibit a striking design.

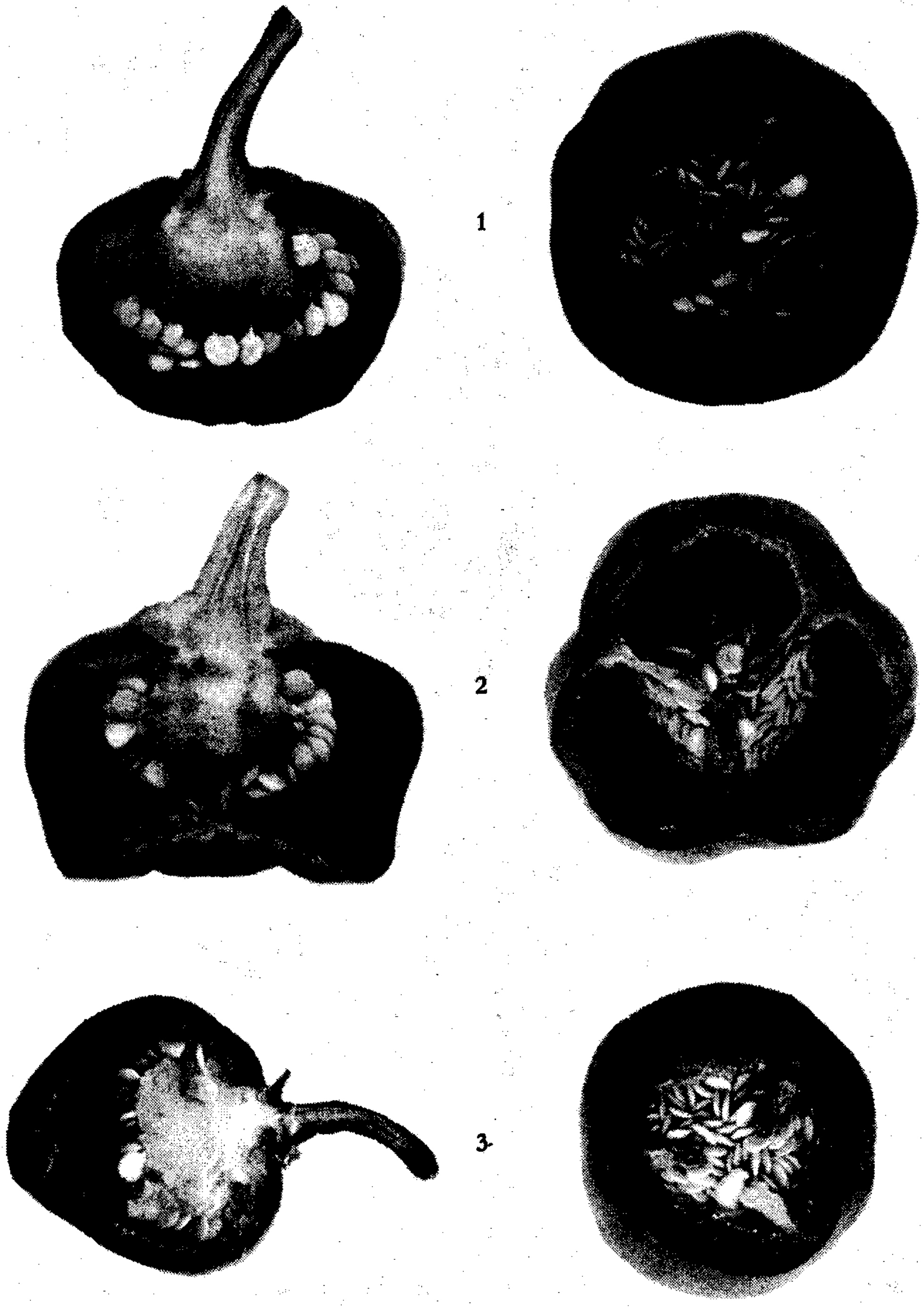

Fig. 2. SPANISH PAPRIKA PODS. 1—Variety *Ramillete*. 2—Variety *Tres Cascos*. 3—Variety *Bola*.

Photographs, Courtesy of the Ministry of Agriculture, Murcia, Spain.

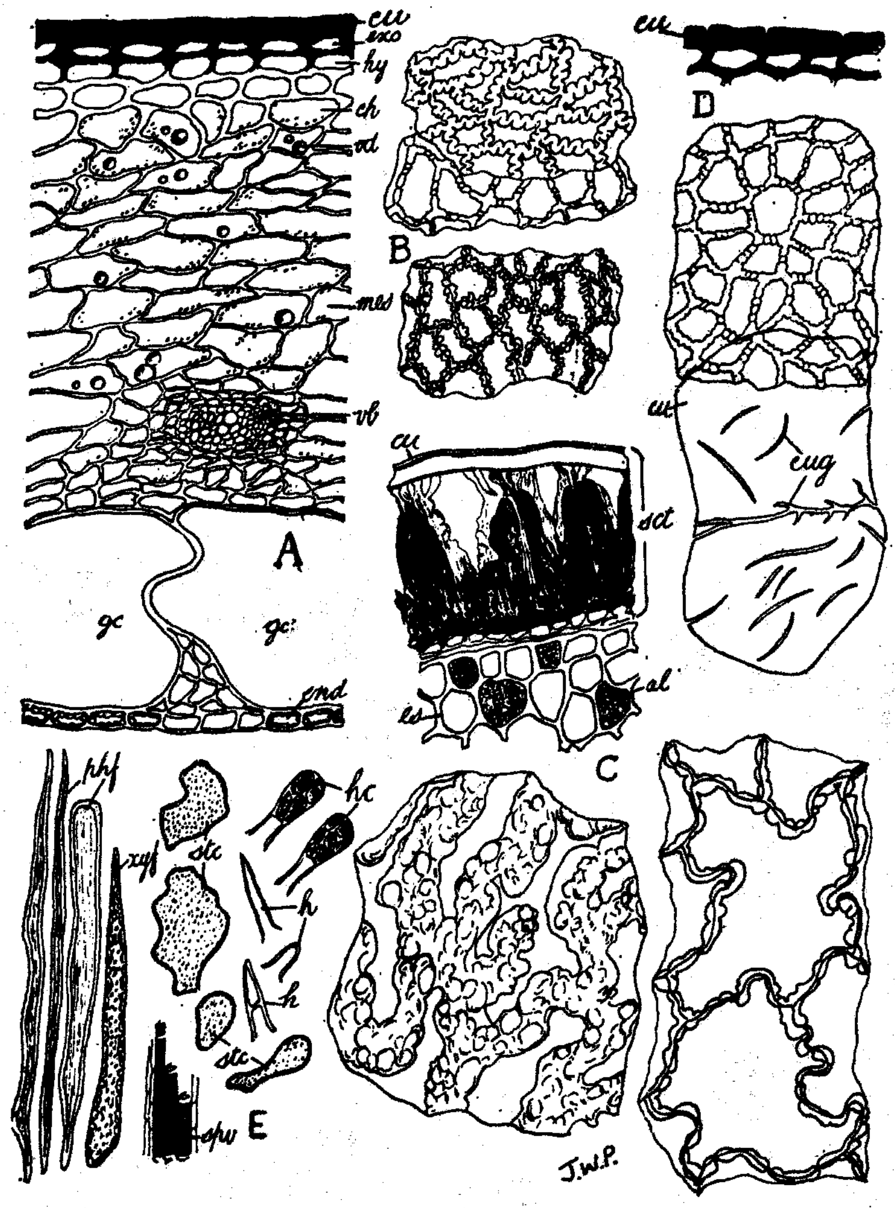

Fig. 3. CAPSICUM. (A) Cross section of pericarp, Hontaka chilli. (B) Surface view of epidermis and hypodermis (above); of endocarp (below). (C) Cross section of portion of seed at ridge (above); surface view of seed coat at ridge (below, left), and of seed coat, flat side of seed (below, right). (D) Paprika, cross section of exocarp illustrating thick cuticle (above); surface view of epidermis and grooved cuticle (below). (E) Fibers, stone cells and hairs of calyx; spiral vessels of fruit.

al, aleurone; ch, chloroplasts; cu, cuticle; cug, cuticle grooves; end, endocarp; es, endosperm; exo, exocarp; gc, giant cell; h, hair; hc, capitate hair; hy, hypodermis; mes, mesocarp; od, oil drops; phf, phloem fibers; sct, seed coat; spv, spiral vessel; stc, stone cells; vb, vascular bundle; xyf, xylem fibers.

III. CARDAMOM

Elettaria cardamomum Maton
Family: *Zingiberaceae*

GENERAL

A perennial, bushy herb reaching a height of about 6 to 12 feet, with a tuberous, horizontal rhizome. Leaves alternate, lanceolate, sheathing, and very long. Flowers arranged in short racemes, corolla tubular, 3-lobed, pale green, androecium with petaloid labellum white in color with pink or purplish veins. Fruit an ovoid capsule, 3-loculed, greenish-brown, and containing several seeds.

The *Mysore* cardamom has large, coarse, dark green leaves with a hard, smooth under-surface. The flower stalks are borne perpendicularly. The fruit is elongated and rarely angled.

The *Malabar* cardamom has large leaves which are silky on the undersurface. The flower stalks lie on the surface of the ground. The fruit is shorter and more globular.

Mysore and Malabar cardamoms are cultivated in southern India and in Ceylon.

The cardamom indigenous to Ceylon is considered to be a variety of the Malabar cardamom. It grows wild in wet forests, and is found especially in the Ratnapura District. Its leaves are coarser than those of the Malabar cardamom and less silky on the under-surface. It has a stem which is distinctly tinged with pink; a short, sparse inflorescence, and a long fruit.

Fully ripe cardamom fruits are a deep yellow in color, but it is the practice to harvest the fruit just before it turns yellow. The fruits are removed individually with the aid of scissors, dried in the sun, clipped to remove pedicel and calyx remains, and sorted and graded according to size and color.

MORPHOLOGY

Cardamom, Dried Unopened Fruit, "Bleached Medium Bold"

Capsule creamy white, oblong-ovoid, 3-sided, from about 8 to 15 mm long, clean, longitudinally wrinkled. Three locules, partitions thin, each locule containing many seeds attached to axile placenta. Pericarp fibrous, papery, and tough.

The unopened capsules have an aromatic odor. The pericarp has a very slight aromatic taste.

Seed

Light reddish-brown to dark reddish-brown, about 3 mm long and from about 2 to 3 mm broad, irregularly 3-sided, angled, transversely wrinkled or furrowed, marked raphe depression, covered by a membranous aril. Perisperm bulky, starchy, white. Endosperm small, pale yellowish-white, of horny consistency and containing a small embryo.

Aroma pleasant and aromatic; taste characteristic, warm, slightly pungent and highly aromatic.

HISTOLOGY

Pericarp

Cross section.

Exocarp. Consisting of epidermis with cells varying in size to about 30 microns, long axis. The epidermis is interrupted in places, probably as a result of damage in the bleaching process.

Mesocarp. Consisting of (a) thin-walled parenchyma cells, irregular but tending to isodiametric or elliptical in shape, and varying in size to about 180 microns, long axis; (b) fibrovascular bundles; (c) occasional bundles of fibers unassociated with vascular tissue; and (d) occasional resin cells.

Endocarp. Consisting of somewhat compressed elliptical or elongated cells. Where the tissues merge into thin locule partitions the cells are small and irregular in shape. The walls of the endocarp cells are slightly thicker than those of the mesocarp cells.

In surface view, the endocarp cells are polygonal in shape with unevenly thickened walls.

Fibrovascular Bundles. The lumen of the fibers varies from about 4 to 66 microns; the walls are thick and pitted. The vessels are spiral, and vary in size to about 50 microns, diameter.

Cell Inclusions. A conspicuous inclusion of the mesocarp parenchyma cells is calcium oxalate. In each cell there occurs 1 or more cystals, solitary, overlying each other when more than one, or in groups, or scattered. Prismatic crystals and crystal sand of calcium oxalate occur in the cells of the locule partitions. Each resin cell contains a lump of resin, pale to dark brown in color, and varying in size from about 44 to 80 microns, long axis.

Seed

Cross section.

Aril. Consisting of 3 layers of nearly rectangular, thin-walled cells containing a pale-colored substance and crystals of calcium oxalate.

In surface view, the cells are greatly elongated.

Seed Coat. Consisting of (a) an epidermis with rectangular cells varying in size to about 25 microns, long axis; (b) collapsed parenchymatous tissue; (c) a layer of large rectangular cells containing globules of oil; (d) compressed parenchymatous tissue; and (e) a conspicuous layer of sclerenchymatous, thick-walled, dark brown, beaker cells, each with a cap or nodule of silica. These cells vary in size to about 33 microns, radial axis, and have an average width of about 16 microns.

In surface view, the cells of the epidermis are elongated, narrow, and have moderately thick walls; the collapsed parenchyma consists of cross cells varying in size to about 135 microns, long axis; the cells of the compressed parenchyma tissue vary in size to about 65 microns, long axis, and have wavy, beaded walls; and the beaker cells are polygonal in shape with the embedded silica clearly visible.

Perisperm. Consisting of somewhat wavy-walled, polygonal cells varying in size to about 88 microns, long axis, and filled with starch. The starch granules are polygonal and vary in size from about 2 to 4 microns; most granules are about 3 microns. Embedded in the starch mass of each cell is a group of calcium oxalate crystals.

Endosperm. The endosperm cells are polygonal with thinner and straighter walls than those of the perisperm cells, and contain a protein substance having a waxy or horny nature. The cells vary in size to about 62 microns, long axis.

Embryo. The embryo is straight. The cells contain aleurone grains and fixed oil.

Ground Whole Fruits of Cardamom

The most important identifying tissues and cell inclusions are (a) spiral vessels and closely grouped fibers of the fibrovascular bundles of the pericarp; (b) parenchyma cells of the mesocarp with crystals of calcium oxalate; (c) resin lumps; (d) elongated, narrow cells of the aril with pale-colored contents and crystals of calcium oxalate; (e) large parenchyma cells containing globules of oil; (f) dark-brown beaker cells of the seed coat with or without silica nodular caps; (g) starch-filled perisperm cells with embedded crystals of calcium oxalate; (h) endosperm cells filled with protein substance; and (i) scattered crystals of calcium oxalate, particles of silica, starch masses, and aleurone grains.

Ground Cardamom Seed

As above with the exception of a, b, and c.

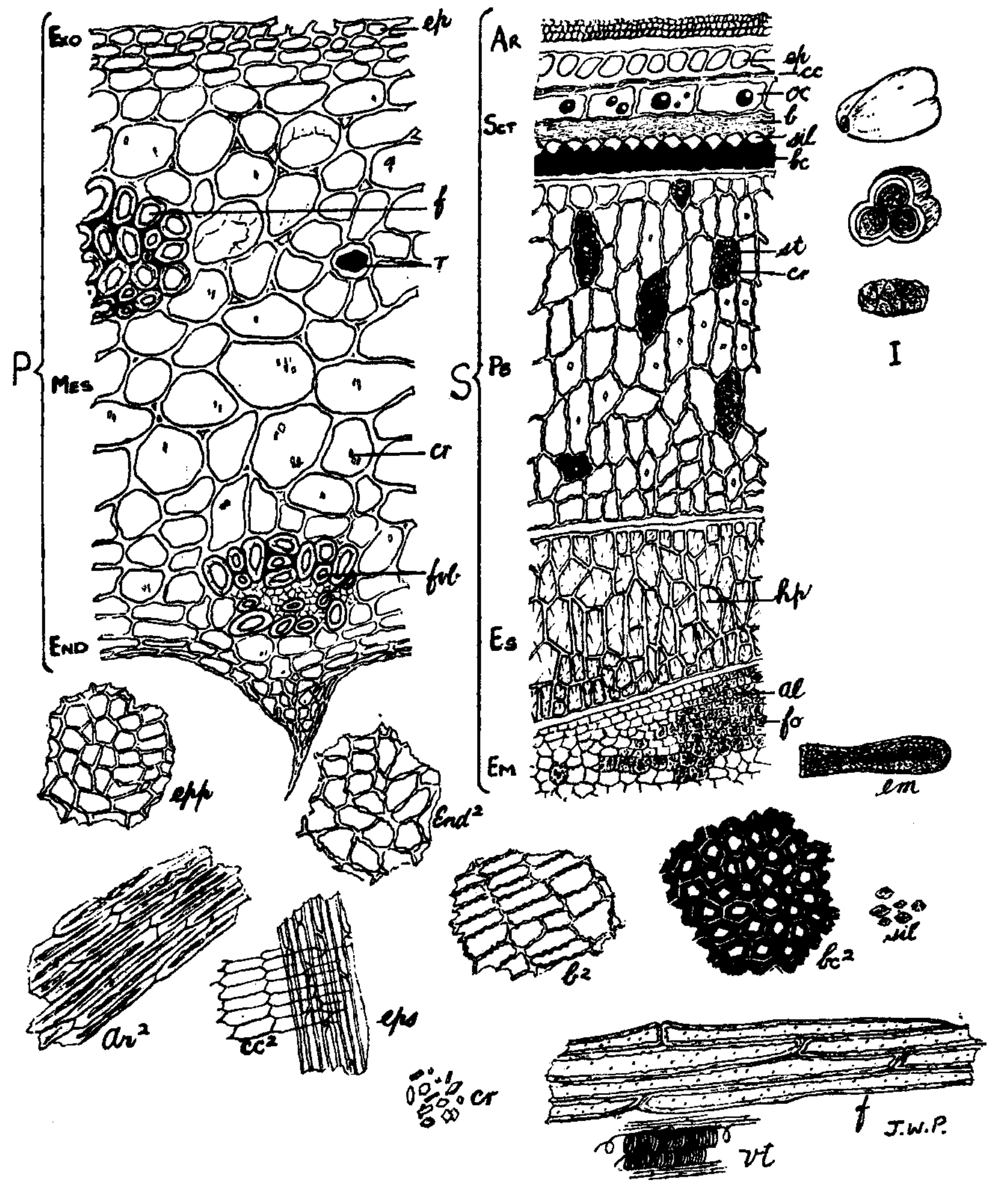

Fig. 4. CARDAMOM. (I) 3-loculed fruit and seeds. (P) Cross section of pericarp. (S) Cross section of seed.

Al, aleurone; Ar, aril (ar², surface view); b, beaded cells (b², surface view); bc, beaker cells (bc², surface view); cc, cross cells (cc², surface view); cr, crystals; em, embryo; End, endocarp (End², surface view); ep, epidermis; epp, epidermis of pericarp, surface view; eps, epidermis of seed coat, surface view; Es, endosperm; Exo, exocarp; f, fibers; fo, fixed oil; fvb, fibrovascular bundle; hp, horny protein; Mes, mesocarp; oc, oil cells; Ps, perisperm; r, resin; Sct, seed coat; sil, silica nodules; st, starch; vt, vascular tissue.

IV. CINNAMON

Cinnamomum zeylanicum Nees
Family: *Lauraceae*

[CEYLON CINNAMON]

GENERAL

The wild cinnamon tree is found in the wet forests of Ceylon up to an elevation of 5,000 feet. It reaches 30 to 50 feet in height; bark thick, rough; branches numerous; leaves reaching about 17 cm in length, ovate or ovate-oblong, margin entire, tip obtuse, petiolate, leathery; flowers inconspicuous, yellow.

Under cultivation, Ceylon cinnamon is kept to bush-like proportions, not higher than 6 to 8 feet. The best cinnamon is grown in the quartz or white sand of the Negombo District, and is generally propagated from seed sown in nurseries. Seedlings are transplanted in the field when about 10 months old, usually when the monsoon rains begin. In 2 or 3 years the shoots are ready for cutting but it is usual to wait until the fourth year to take the first crop. After cutting, more shoots arise providing a succession of wood. The yield diminishes after the tenth year. Cutting takes place twice a year and the greater part of the crop is from 2 year old shoots.

The bark is twice slit longitudinally, one cut on each side of the shoot, permitting its removal in two strips of similar dimension. The pieces are then put together, the outer side of one piece against the inner side of the other, bundled, closely bound together, and allowed to "ferment" for 24 hours. Following this process each length of bark is placed over a cylindrical stick and the outer bark removed with the aid of a curved knife. After a short interval the pieces of bark are placed one within the other and left to dry. As the bark dries it contracts, curls inwards, and gradually acquires the form of a "pipe" or "quill." The bark is graded according to texture and color before quilling. First quality Ceylon cinnamon quills are obtained from the thin bark of tender shoots.

MORPHOLOGY

Ceylon Cinnamon

Compound Quills, Grade "0000." Yellowish-brown, cylindrical, compound quills, approximately 1 m in length and 10 mm in diameter. Scraped, smooth, thin, rolled bark with occasional scars. Fine, light-colored wavy lines running lengthwise and clearly visible. A pleasing, fragrant odor and a warm, sweet, aromatic taste.

Ceylon Cinnamon Quillings. Quillings are broken pieces of compound quills of various grades. The pieces vary considerably in size, being about 5 to 15 or 20 cm in length and about 10 to 25 mm in diameter. Many of the quillings are completely broken down. For aroma and taste they approach but lack the fullness of that of the sound Ceylon cinnamon quills.

Ceylon Cinnamon Featherings. Featherings are short shavings and small pieces of bark left over in the processing of the inner bark into quills. Collectively, featherings present a shade darker color than the quills and a shade lighter than the chips. Featherings have a flavor similar to that of the quillings.

Ceylon Cinnamon Chips. Mature, unpeelable bark is utilized in making "chips." Cinnamon chips, as the name implies, are small pieces of bark; they are grayish-brown on the outside and a lighter brown on the inside. Ceylon chips are deficient in both aroma and taste and are not to be compared to the quills for flavor.

HISTOLOGY

In the preparation of Ceylon cinnamon bark the cork and cortex tissues are removed leaving nothing to the outside of the pericycle except a few fragments of cortex cell walls.

In cross section, the bark consists of (a) pericycle; and (b) phloem. The pericycle tissue consists of stone cells and fibers. The phloem tissue consists of (a) parenchyma cells containing starch; (b) sieve tubes; (c) fibers; (d) oil secretion cells; and (e) phloem ray cells containing prismatic crystals of calcium oxalate.

Pericycle

The stone cells of the pericycle are abundant and form an almost unbroken ring; they vary in shape, and in size to about 150 microns, long axis. The fibers occur in groups among the stone cells.

Phloem

The phloem parenchyma cells are irregular in shape, thin-walled, and contain starch. The starch granules are mostly round in shape but some are truncated; they vary from about 6 to 9 microns in diameter with the former size predominating; the hilum is central.

The sieve tubes are best examined in longitudinal section under medium power. This permits a satisfactory study of the cells and the sieve plates.

Phloem fibers are numerous. Seen in longitudinal section the phloem fibers vary in length from about 100 to 700 microns, and in width from about 15 to 31 microns, with the majority being from about 350 to 550 microns in length, and from about 22 to 28 microns in width at the widest part of the fiber.

The oil cells, in cross section, are oval or nearly round, and vary in size from about 40 to 80 microns, long axis or diameter. In longitudinal section the oil cells are oval and vary in size from about 90 to 150 microns, long axis.

The phloem rays consist of radial rows of somewhat rectangular parenchymatous cells containg small, prismatic crystals of calcium oxalate.

Ground Ceylon Cinnamon

The most important identifying characteristics of ground Ceylon cinnamon are (a) numerous phloem fibers; (b) numerous stone cells; and (c) starch, smaller and less abundant than that of cassia; granules occurring singly and in small aggregates; clearly visible with transmitted light, poorly refractive to polarized light.

With polarized light the fibers and stone cells exhibit striking color and brilliance, appearing white, yellow, reddish-brown, or turquoise blue. Rotating the analyzer will bring these colors into view.

V. CASSIA

Family:—*Lauraceae*

MORPHOLOGY

China Cassia (*Cinnamomum cassia* Blume)

Rolled bark in pieces of varying lengths from about 25 to 38 cm. Most China cassia bark is about 3 mm thick but it varies from about 2 to 6 mm. Unscraped China cassia is gray or grayish; surface rough and irregular, coarse in appearance. Scraped China cassia is light reddish-brown with occasional patches of gray; smooth or nearly smooth.

The aroma of China cassia is faintly aromatic; the taste is sweet, aromatic, pungent, and slightly astringent.

Saigon Cassia (*Cinnamomum loureirii* Nees)

Grayish-brown bark in single or double quills varying in length from about 15 to 30 cm; in diameter from about 10 to 38 mm, and in thickness from about 1 to 6 mm. The thin bark is slightly rough and shows longitudinal wavy ridges, scars marking former branch joints, and numerous wart-like protuberances. The thick bark is grayer than the thin, very rough, and with no wavy ridges.

The aroma of Saigon cassia is agreeable and aromatic; the taste is sweet, aromatic, pungent, and slightly astringent.

Batavia (Indonesia) Cassia (*Cinamomum burmanni* Blume)

Cylindrical double quills of reddish-brown bark varying in thickness from about 1 to 5 mm. The quills are about 13 mm in diameter and of various lengths depending upon the grade, long or short stick. The bark is comparatively smooth. Scars marking former branch joints are apparent, but no wavy lines or ridges. The quills of high quality Batavia cassia are of good appearance, straight and regular; those of inferior grades are frequently twisted and irregular.

The odor of Batavia cassia is agreeable and aromatic; the taste is sweet and pungent.

Batavia cassia is frequently referred to as Batavia cinnamon.

HISTOLOGY

China Cassia

In cross section, the unscraped bark of China cassia consists of (a) cuticle; (b) epidermis; (c) cork; (d) cortex; (e) pericycle; and (f) phloem. (In scraped cassia the cuticle, cork, and more or less of the cortex tissue is absent.)

Cuticle. The cuticle is well-developed and varies in thickness.

Epidermis. The cells of the epidermis are tangentially oblong-rectangular; have dark contents, and vary in size from about 10 to 25 microns, long axis.

Cork. The cork tissue consists of stone cells, thin-walled cells, and arch cells. The thickening of the stone cells is laid down fairly evenly; that of the arch cells occurs on the outer wall, causing the archlike appearance. The thin-walled cells of the cork layer are disorganized.

Cortex. The parenchyma cells of the cortex are irregular in shape, and vary in size; the cell walls are about 4 or 5 microns thick. Intercellular spaces are frequent. Stone cells are numerous in the cortex, and occur singly and in groups. They vary in shape, and in size from about 25 to 150 microns, long axis. Many are characterized by the thinness of one wall, frequently the outer wall. Starch granules occur in the parenchyma cells and in some stone cells.

Pericycle. Pericycle stone cells are numerous, and occur in groups; they do not form an unbroken ring. The walls of these stone cells are, for the most part, more evenly thickened than those of the stone cells occurring in the cortex. The fibers are similar to the phloem fibers but somewhat thicker. They occur in groups but are not abundant.

Phloem. Phloem fibers are not numerous. In longitudinal section, the phloem fibers vary in size but are mostly from about 440 to 690 microns in length, and from about 27 to 35 microns in width. The sieve tubes, in cross section, are irregularly compressed, but are easily indentified in longitudinal section. The parenchyma cells are irregular in shape; the walls are about 4 to 5 microns thick; starch is present in these cells. The phloem rays consist of radial rows of rectangular, parenchymatous cells containing small, prismatic crystals of calcium oxalate.

The *starch* of China cassia consists of round granules, some truncated; cen-

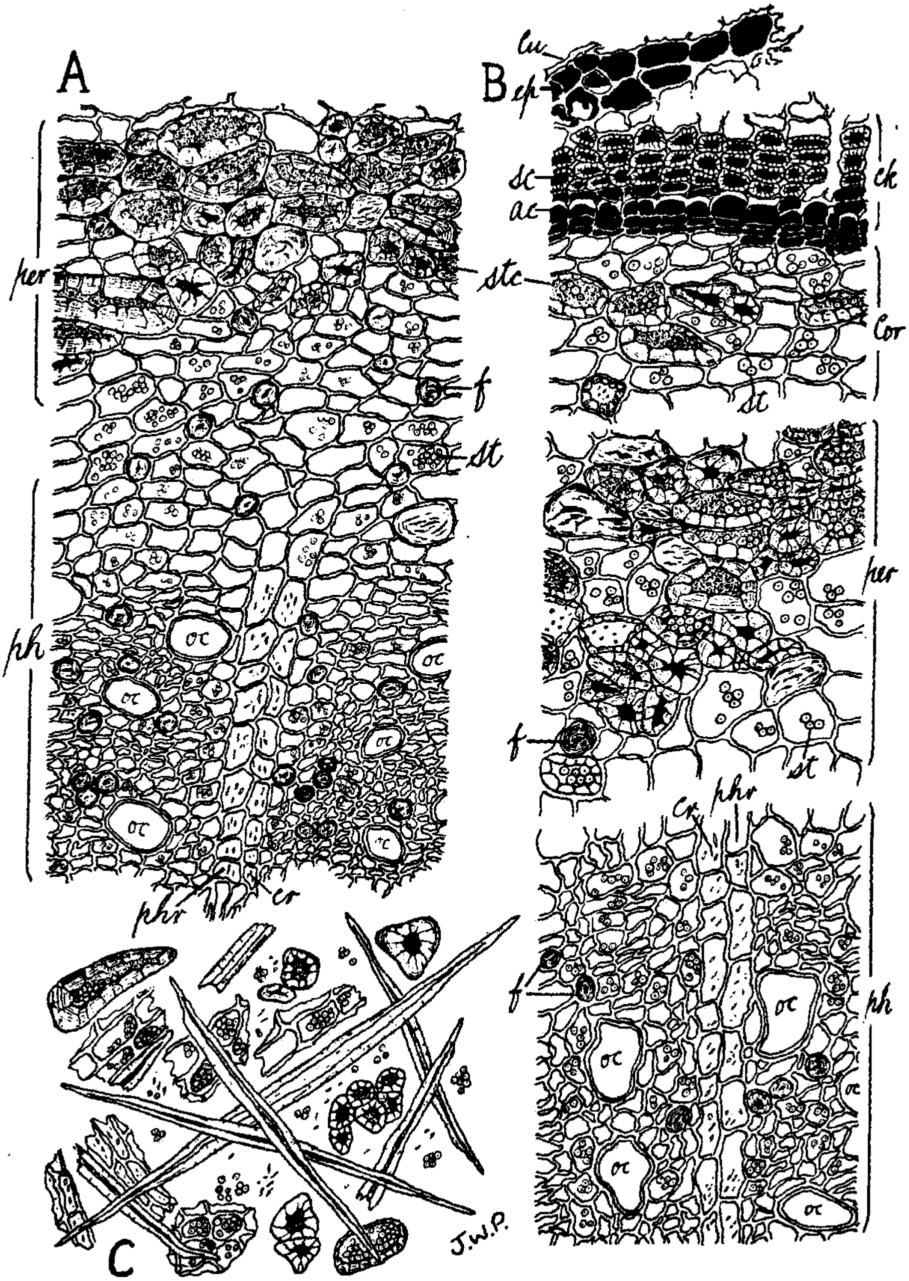

Fig. 5. CINNAMON AND CASSIA. (A) Ceylon cinnamon bark, cross section. (B) China cassia (Kwangsi) bark, cross section. (C) Ground Ceylon cinnamon, illustrating fibers, stone cells, fragments of parenchyma and ray cells, starch, and crystals.

ac, arch cells; ck, cork; cor, cortex; cr, crystals; cu, cuticle; ep, epidermis; f, fibers; oc, oil cells; per, pericycle; ph, phloem; phr, phloem ray; sc, stone cork; st, starch, stc, stone cells.

tral hilum; and varying in size to about 15 microns in diameter. With polarized light the granules exhibit a clear, distinct cross.

Saigon Cassia

The structure of Saigon cassia is similar to that of China cassia with the following differences:

(1) Pericycle stone cells are generally larger with fairly even thickening. Elongated, thick-walled stone cells up to about 225 microns, long axis, occur in groups and are characteristic of Saigon cassia.
(2) The oil cells are larger.
(3) Phloem fibers are fewer and reach greater widths.
(4) The cell contents are dense and dark, particularly in the thick bark.
(5) Starch granules vary in size to about 22 microns diameter in the thick bark; to about 15 microns in the medium; and to about 12 microns in the thin.
(6) The crystals in the ray cells are larger in the thick bark; somewhat larger in the medium; similar in size in the thin but mostly needlelike.

Batavia (Indonesia) Cassia

The structure of Batavia cassia is similar to that of China cassia with the following differences:

(1) The starch granules vary in size to about 22 microns diameter.
(2) Ray crystals are mostly oblong, varying in size to about 14 microns, long axis, and 6 microns, short axis.

Ground Cassia

Samples of China, Saigon, and Batavia cassia will show under the microscope fragments of the tissues just described. A sample of ground cassia might show the fragmented tissues of all three, for it is the general practice to blend these barks in the preparation of ground cassia. Assuming a blended product, the most important identifying characteristics of ground cassia are (a) numerous stone cells, some very large, and many containing starch; (b) fibers, not numerous but up to about 45 microns at their widest part and occasionally larger; (c) abundant starch, with granules up to about 22 microns diameter; round, some truncated; hilum central; occurring singly and in small aggregates; clearly visible with ordinary transmitted light; exhibiting a bright cross with polarized light; and (d) numerous prismatic crystals of calcium oxalate.

VI.—CASSIA BUDS

MORPHOLOGY

Cassia Buds are the dried, unripe fruits of *Cinnamomum cassia* Blume, and *Cinnamomum loureirii* Nees. They vary from about 6 to 14 mm in length, the width of the cup varying from about 4 to 6 mm. The immature fruit is snugly enclosed within a grayish-brown calyx with only the brown, dome-like upper surface of the pericarp visible. The exposed pericarp is smooth and lustrous, with the small, protuberant base of the style in the center. The hidden pericarp, seen when removed from the calyx, is markedly wrinkled. The calyx is cup-shaped, expanding from the calyx tube; rough, wrinkled, very hard, and frequently with pedicel attached.

Cassia buds have a slight cinnamon-like odor, and a sweet, warm, pungent taste akin to that of cassia bark.

HISTOLOGY

[LONGITUDINAL SECTION THROUGH CALYX, PERICARP, AND SEED COAT]

Calyx

Calyx Lobes. The lobes of the calyx consist of the following tissues:

(a) An outer epidermis of small cells, rectangular or nearly so, with thick outer walls. In surface view, these cells are polygonal, thick-walled, and divided by thin cross walls. Hairs are not present.

(b) A cortex of parenchyma cells, secretion cells, and occasional stone cells. The parenchyma cells vary in size to about 75 microns; the secretion cells to about 66 microns, and the stone cells to about 80 microns, long axis.

(c) Fibrovascular tissue consisting of short and long fibers, phloem, xylem, and phloem and xylem parenchyma. The short fibers are porous with numerous pits; they vary considerably in shape and size. The long fibers are pitted and striated; they vary in length to about 1500 microns, and in width to about 36 microns. The phloem cells are numerous. The xylem vessels are small, and consist of annular, spiral, and reticulate types.

(d) An inner epidermis of small, rectangular cells; in surface view similar to that of the outer epidermis.

Calyx Tube. The calyx tube consists of the following tissues:

(a) An epidermis of small cells, rectangular or nearly so, with thick outer walls. In surface view, the epidermal cells are polygonal with thick parallel walls and thin cross walls. Hairs are present. The hairs are unicellular, straight or curved, some with curled tip, and up to about 156 microns in length.

(b) A cortex of parenchyma cells, isodiametric, to about 45 microns diameter; secretion cells to about 66 microns, and occasional stone cells. The cell contents are light to dark brown in color. Starch is present but not abundant; the granules are small, to about 6 microns. The presence of starch is masked by the dark cell contents but it is readily seen after bleaching the section and staining with iodine. Small prismatic crystals of calcium oxalate are distributed throughout the cortex.

(c) A pericycle marked by a ring of fibers. The ring is broken by the parenchymatous tissue of the pith rays. The fibers are thick-walled and up to about 66 microns in diameter.

(d) Fibrovascular tissue similar to that of the lobes described above.

(e) Pith of isodiametric, parenchymatous cells and occasional stone cells.

Pericarp

The pericarp consists of the following tissues:

(a) A sclerenchymatous epicarp. The cells have thick outer walls and thin inner walls. The sclerenchymatous epicarp forms a continuous tissue except where it is interrupted by the ovary canal at the apex of the fruit, and where it merges with the parenchymatous tissue of the calyx at the base of the fruit. The radial thickness of the sclerenchymatous layer varies from about 45 to 58 microns.

(b) A mesocarp of stone cells, parenchyma cells, secretion cells, and vascular tissue. The stone cells vary in size and shape; they underlie the epicarp and are most numerous in the regions adjoining the ovary canal. The parenchyma cells occupy the major part of the mesocarp; they tend to be elliptical or isodiametric in shape and they vary in size to about 66 microns. The cell contents vary in color from light to dark brown. Small prismatic crystals of calcium oxalate are distributed throughout the parenchymatous tissue. The secretion cells are numerous.

(c) An endocarp of sclerenchymatous tissue except in the basal region of the fruit where it is parenchymatous. The endocarp cells in the region of the ovary canal are large and thick, almost without lumen. The remaining sclerenchymatous endocarp consists of more regular, rectangular-shaped cells which contain large prismatic crystals of calcium oxalate.

Seed Coat

The seed coat consists of the following tissues:

(a) An outer tissue of deeply pigmented (dark-brown) parenchyma cells. There are about 6 layers of cells in the area facing the ovary canal of the pericarp, and about 4 layers on the sides. The cells are tangentially elongated to about 90 microns. The outer walls of the cells of the outermost layer are somewhat thickened. In the basal region the cells are less heavily pigmented and become more or less isodiametric in shape.

(b) An almost complete tissue of reticulated cells. In the upper part of the seed these cells are arranged in palisade fashion, the innermost cells being the longest, up to about 100 m microns radial axis. On the sides the reticulated cells are all much the same and up to about 33 microns, long axis. Reticulated cells are not evident in the basal region.

(c) An incomplete, parenchymatous tissue underlying the reticulate cells. Five or 6 layers of irregular-shaped cells are evident. In size, these cells become larger in three successive stages. The outer layer consists of cells to about 28 microns, the next or second layer consists of cells to about 36 microns, and the cells of the remaining layers are up to about 75 microns, long axis. The walls of the outer and second layers of cells are thinner than those of the remaining cells of this tissue. In surface view, the cells of this tissue are polygonal in shape. Calcium oxalate crystals are present, and with polarized light appear as 4-pointed, or more, rosettes varying in size to about 10 microns. Other seed tissues are not present.

Pedicel

In cross section the pedicel consists of the following tissues:

(a) Epidermis. The epidermal cells are small and rectangular with thick outer walls. Hairs are present. In surface view, the epidermal cells are quadrilateral to oblong-rectangular or nearly so, thick-walled, and divided by cross walls either thick or thin. The cells vary in size to about 30 microns, long axis.

(b) Cortex. The cortex consists of isodiametric, thin-walled parenchyma cells with dark contents; secretion cells, and occasional stone cells.

(c) Pericycle. Marked by an almost continuous ring of fibers, small but thick-walled.

(d) An almost complete ring of fibrovascular tissue.

(e) A pith of isodiametric parenchyma cells. Pith rays radiate outwards and traverse the fibrovascular tissue and the pericycle fiber zone.

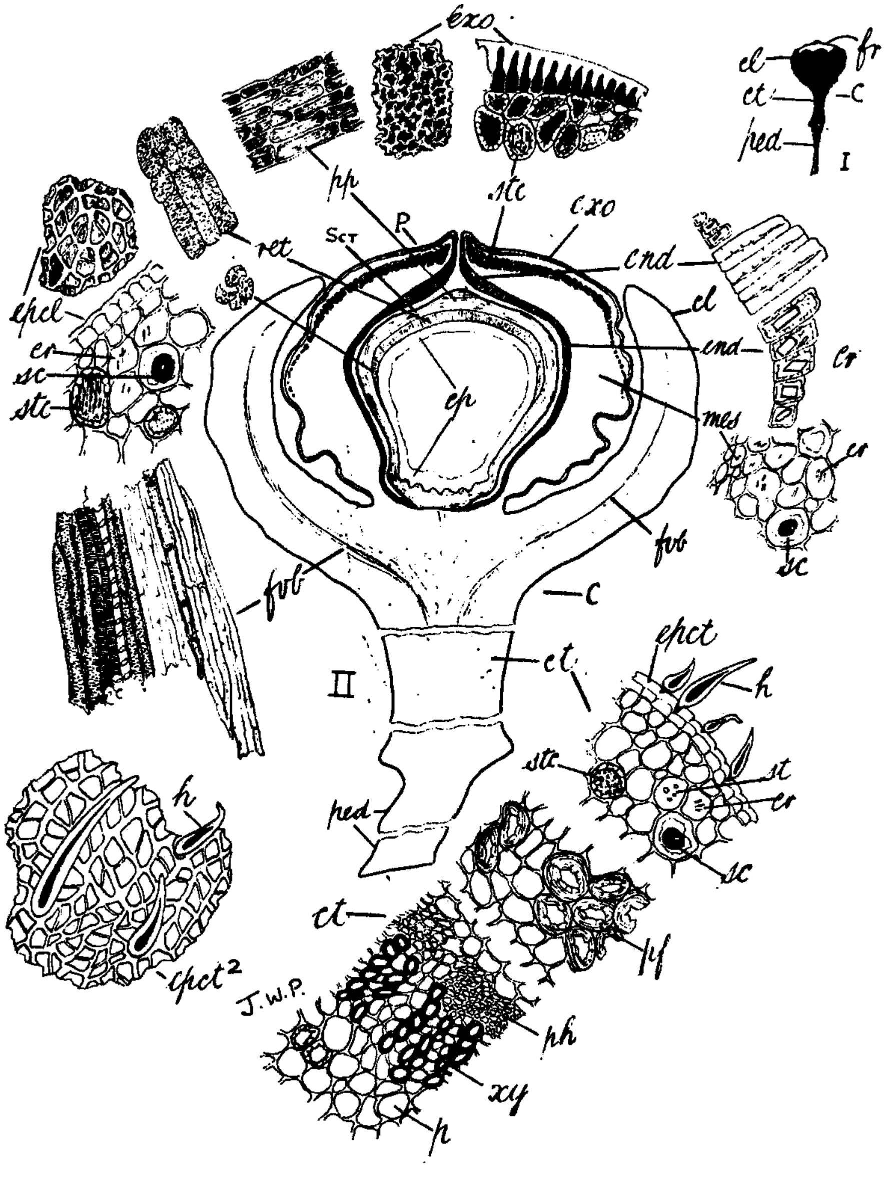

Fig. 6. CASSIA BUDS. I—Cassia bud. II—Longitudinal section of calyx and fruit.

c, calyx; cl, calyx lobe; cp, compressed parenchyma; cr, crystals; ct, calyx tube; end, endocarp; epcl, epidermis of calyx lobe; epct, epidermis of calyx tube; exo, exocarp; fr, fruit; fvb, fibrovascular bundle; h, hair; mes, mesocarp; p, pith; P, pericarp; ped, pedicel; pf, pericycle fibers; ph, phloem; pp, pigmented parenchyma; ret, reticulated cells; sc, secretion cells; sct, seed coat; st, starch; stc, stone cells; xy, xylem.

VII. CLOVE

Caryophyllus aromaticus L.
Family: *Myrtaceae*

GENERAL

The clove tree reaches 16 to 40 feet in height at maturity. It is an evergreen, pyramidal, with a thin, smooth, grayish bark. The leaves are opposite, elliptical to obovate-oblong, accuminate at both ends, blade from about 7.5 to 12.5 cm long and 2.5 to 5 cm wide, entire, glandular-punctate, petiolate, smooth, lustrous, and fragrant. Mature leaves are dark green.

The flowers are arranged in paniculate cymes, fragrant, and produced in either of two seasons, July to October, and November to January; petals 4; stamens numerous; ovary inferior; fruit a purple drupe about 25 mm in length and 12 mm in breadth, and usually containing a single seed. The fruit is called "Mother of Cloves."

The cloves of the spice trade are the unopened flower buds, picked when they turn red at the base. The flower stalks are the "clove stems" of commerce.

Khoker cloves are those buds which under bad drying and storage conditions become darker, rather musty, and finally pale and wrinkled. Cloves are graded according to appearance and impurities present. Zanzibar cloves are graded Special, No. 1, No. 2, and No. 3, as follows:

	Extraneous Matter (stems, mother of cloves, foreign & inferior matter)	*Khoker*	*Moisture*
	%	%	%
Special Grade	3	2	16
Grade No. 1	5	3	16
Grade No. 2	5	7	16
Grade No. 3	5	20	16

MORPHOLOGY

In shape, the clove is said to resemble a round headed nail; the word clove is derived from the French "clou," Latin "clavus," a nail. Cloves are reddish-brown in color, vary from about 12 to 19 mm in length, and consist of hypanthium, receptacle, calyx of 4 calyx teeth, corolla of 4 unopened petals enclosing an indefinite number of stamens and a central columnar style. The ovary, situated just below the receptacle, is inferior, 2-loculed, with central placenta and numerous ovules. The hypanthium proper is that part of the fruit axis below the calyx and ovary, an extension or enlargment of the recptacle without loculi. The entire portion of the fruit axis below the calyx is sometimes called the gynophore, calyx tube, stemlike receptacle, or receptacle. In some cloves the hypanthium is clearly or obscurely 4-sided, in others it is compressed. Sound dried cloves are bold, plump, somewhat rough to the touch but not wrinkled or shrivelled.

Dried cloves have a very strong aromatic odor, and a hot, pungent, aromatic taste.

HISTOLOGY

Hypanthium (a)

Cross section through the ovary (considered part of the hypanthium for this purpose). The tissues consist of:

(a) Epidermis of nearly rectangular cells varying in size from about 9 to 15 microns, long axis, with cuticle.

(b) Volatile oil zone consisting of oval or elliptical cavities varying in size from about 112 to 260 microns, long axis, and from about 70 to 190 microns, short axis. The cavities are interspersed with parenchyma cells pressured into a flattened or elongated shape.

(c) Parenchyma cells with moderately thick walls, and varying in size to about 45 microns, long axis.

(d) Zone of fibrovascular tissue; in longitudinal section the bundles consist of spiral vessels; phloem tissue, and thick-walled phloem fibers accompanied by crystal fibers containing rosette crystals of calcium oxalate.

(e) Bilocular ovary with central placenta and numerous ovules.

Hypanthium (b)

Cross section through hypanthium below the ovary.

The tissues are as above from the epidermis to the fibrovasular bundle zone inclusive. The remaining tissues are:

(a) Inward from the fibrovascular bundle zone there is a mass of spongy, thick-walled parenchyma tissue with chains of thick-walled parenchyma cells and large intercellular spaces.

(b) An inner zone of fibrovascular tissue with small vessels and a few phloem fibers.

(c) Pith, consisting of parenchymatous cells, many containing rosette crystals of calcium oxalate.

In surface view, the epidermal cells of the hypanthium are polygonal or irregular in shape. Stomata are numerous.

Corolla

The corolla consists of:

(a) An outer and inner epidermis with small cells.

(b) Mesophyll of parenchyma tissue with rosette crystals of calcium oxalate.

(c) Numerous volatile oil cavities, in size about 60 to 70 microns, long axis.

(d) Vascular tissue.

In surface view, the epidermal cells of the corolla are small, polygonal or irregular in shape, with walls of uneven thickness and occasional beading. The oil cavities are strikingly conspicuous.

Stamens

Consisting of:

(a) Filament, with small, longitudinally oblong-rectangular cells varying in size to about 10 microns, long axis; central vascular bundle; volatile oil cavities; and rosette crystals of calcium oxalate.

(b) Anther. The anthers are noteworthy for their reticulated cells. Rosette crystals of calcium oxalate also occur in the anthers.

(c) Triangular pollen grains, in size from 15 to 21 microns.

In surface view, the reticulated cells of the anthers are noteworthy, as are the masses of rosette crystals of calcium oxalate in the region of dehiscence.

Clove Stems

In cross section consisting of:

(a) Epidermis with rectangular cells varying in size to about 24 microns, long axis, occasionally larger; and cuticle.

(b) Hypodermis, with stone cells thickened on the inner side. This tissue stains yellow with chlor-zinc-iodine after bleaching.

(c) Zone of numerous volatile oil cavities varying in size from about 120 to 160 microns, long axis.

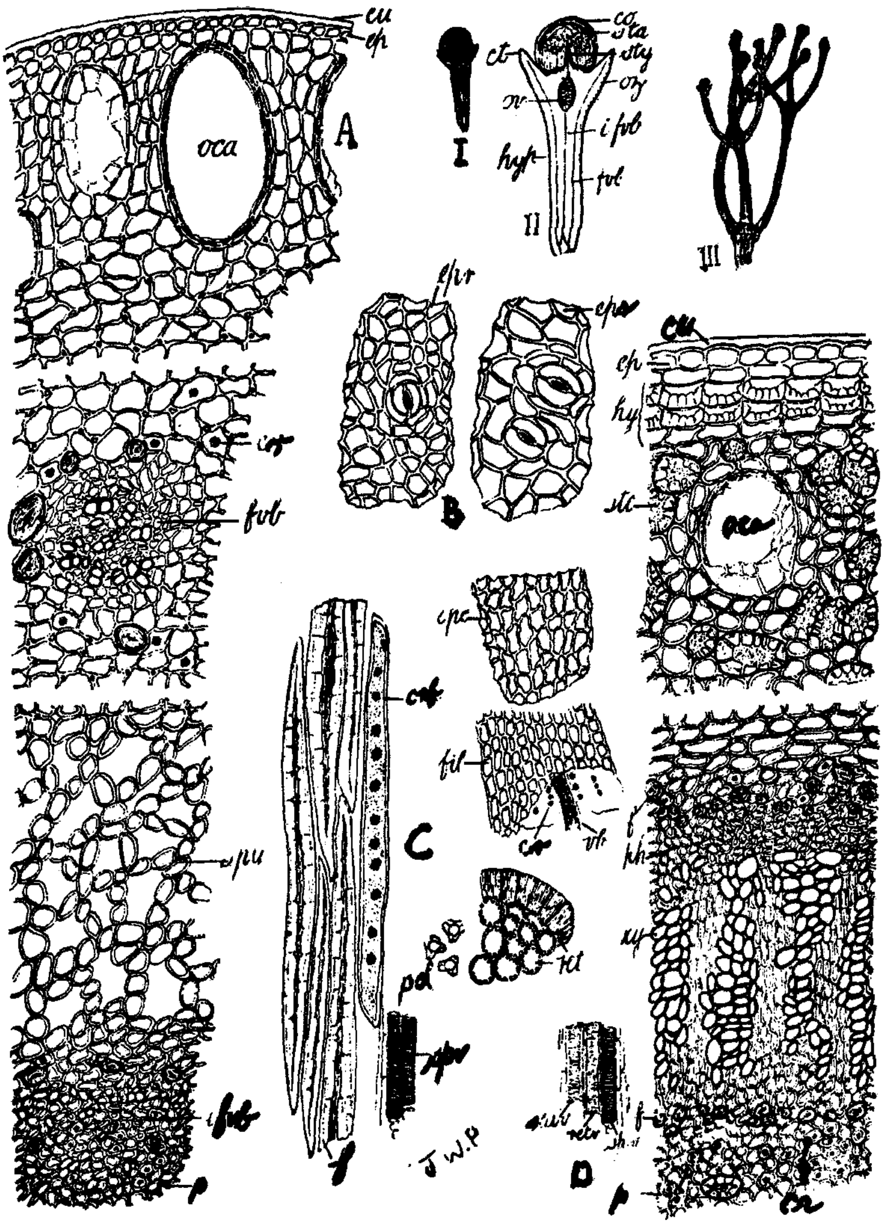

Fig. 7. CLOVE. I—Clove. II—Clove, longitudinal section. III—Clove stems. (A) Cross section of hypanthium below ovary.—(B) Surface view of epidermis of clove (left); of epidermis of stem (right).—(C) Fibers and spiral vessels of clove (left); epidermis of corolla, surface view (above, right); filament (center); reticulated cells of anther (bottom, right).—(D) Cross section of stem (right); vascular tissue (above).

co, corolla; cr, crystal; ct, calyx teeth; cu, cuticle; ep, epidermis; epc, epidermis of corolla; epr, epidermis of hypanthium; eps, epidermis of stem; f, fibers; fil, filament; fvb, fibrovascular bundle; hy, hypodermis; hyp, hypanthium; ifvb, inner fibrovascular bundle; oca, oil cavity; ov, ovary; oz, oil zone; p, pith; ph, phloem; pol, pollen; ret, reticulated cells; retv, recticulated vessel; crf, crystal fiber; scav, scalariform vessel; spv, spiral vessel; spy, spongy parenchyma; sta, stamen; stc, stone cells; sty, style; vb, vascular bundle; xy, xylem.

(d) Parenchyma tissue with cells varying in size from about 15 to 66 microns. Many large stone cells varying from round to elongated occur in this tissue.

(e) Fibrovascular tissue. The vessels vary in size to about 30 microns in diameter, and are arranged in radial rows; scalariform, reticulate, and spiral vessels are present.

(f) Pith, consisting of thick-walled parenchymatous cells with small intercellular spaces, and rosette crystals of calcium oxalate.

Ground Cloves

The most important identifying characteristics of ground cloves are fragments of epidermis tissue, reddish-brown in color; parenchymatous tissue with volatile oil cavities; spiral vessels; thick-walled fibers; crystal fibers; rosette crystals of calcium oxalate; corolla tissue with numerous oil cavities; reticulate cells of anthers; and triangular pollen grains.

As 5 per cent of clove stems are premitted in the ground product it is to be expected that some fragments of the stem tissues will be present. Of these, the most important are the stone cells and the scalariform and reticulate vessels.

Cloves contain no starch. Clove stems contain a very small quantity of starch; the granules are round, about 15 microns in diameter, hilum central, and exhibit a clearly marked cross with polarized light.

VIII. GINGER

Zingiber officinale Roscoe
Family: *Zingiberaceae*

GENERAL

An herbaceous perennial consisting of an underground stem or rhizome which produces erect, leafy shoots 1 to 3 feet high.

Leaves alternate, lanceolate or linear lanceolate, acute, smooth, sessile, sheathing, light green, and up to about 8 inches in length.

Flowers borne in a bracteal, imbricated spike, terminating a leafless stem reaching to about 12 inches in height. Flowers situated in the axils of large, greenish-yellow obtuse bracts, small, few, usually arising one or two at a time yellowish and speckled, with a purplish lip also speckled; evanescent. The fruit is an oblong capsule but it is rarely produced.

The method of harvesting and preparing ginger for market varies in the different countries of cultivation. In general, when the plant is about 9 months old and the green leafy stems commence to turn yellow and cessation of growth is evident the rhizomes are lifted from the earth, cleared of all adhering matter by washing, blanched, and then sun dried. Some producers scald the rhizomes in hot water and then dry them in the sun. Others scald the rhizomes, and then peel or scrape them to remove the cork before drying in the sun. Scraping is thought by some to be a better method than peeling because of the probable loss of aromatic constituents through accidental cutting into the cortex. The rhizomes are usually spread out on some framework to dry slowly in the sun; if spread upon the ground there is always the danger of spotting, blackening, and mold loss developing from the dampness of the earth. It requires about 6 to 8 days to dry the rhizomes sufficiently for market.

In the West Indies it is held that the rhizomes should not contain more than 7 to 12 per cent moisture when ready for market. With a higher moisture content than this, they say, the ginger is liable to ferment. Care is taken not to fracture the rhizomes. Chemical methods of drying are not employed.

Two forms of ginger are exported from Jamaica, the peeled and unpeeled ginger. The peeled ginger is prepared by scalding the rhizomes in hot water and then removing the epidermis with a knife. Jamaica ginger is graded No. 1, No. 2, No. 3, and Ratoon. The last mentioned is an inferior grade of ginger consisting of smaller and more fibrous pieces.

African ginger for export is examined by the produce inspection branch of the Agricultural Department and must conform to the minimum standard of quality laid down by the government of Sierra Leone.

India has three grade classifications for their export ginger, depending upon the tract of production, color, and fiber content of the rhizomes.

MORPHOLOGY

Jamaica Ginger

Rhizomes very light buff in color, and varying in length from about 6 to 9 cm; shape irregular, branched or palmate; divested of cork and epidermal tissue; clean, hard, and somewhat fibrous.

The odor of Jamaica ginger is agreeable, aromatic, and somewhat pungent; the taste is aromatic, pungent, biting.

African Ginger

Rhizomes darker in color than Jamaica ginger, and not completely scraped. Rhizomes complete, dry, plump, with cork removed from the sides only.

African ginger lacks the fine aroma of the Jamaica product but it is very pungent.

Indian Ginger, Cochin Ginger

Rhizomes to about 12 cm in length, cork partly removed on the flattened sides; color, light brown; patches of cork very light brown, wrinkled. **Calicut Ginger:** Rhizomes vary in color from dark yellow to light brown; cork removed from the sides.

The odor of Indian ginger is aromatic, the taste is strongly aromatic and pungent.

Japanese Ginger

Rhizomes resemble those of Cochin ginger in appearance, but the Japanese product is usually limed.

Japanese ginger is weakly aromatic and weakly pungent.

HISTOLOGY

Jamaica Ginger, Scraped

In the preparation of this product the epidermis, hypodermis, and cork are removed, and the spice consists of (a) cortex; (b) endodermis; (c) pericycle; and (d) central cylinder.

Cross section:

Cortex. Consisting of (a) thin-walled parenchyma cells with starch; the starch granules are smallest in the outer cortex tissue; (b) brown-colored oleoresin cells scattered throughout the cortex; and (c) fibrovascular bundles.

Endodermis. An unbroken ring of tangentially elongated cells with thickened, suberized radial walls.

Pericycle. An unbroken ring of tangentially elongated cells situated on the inner side of the endodermis.

Central Cylinder. In the outer cylinder tissue, adjoining the pericycle there is a vascular bundle zone, no fibers. Fibrovascular bundles and oleoresin cells occur in the central region of the cylinder. The ground tissue of the central cylinder consists of thin-walled parenchyma cells containing starch.

The fibrovascular bundles are large. In longitudinal section, the fibers are long with moderately thick walls and wide lumen. The vessels are large and mostly scalariform, excepting in the vascular bundle zone adjoining the pericycle where large reticulate, scalariform, and some spiral vessels occur.

Starch is abundant. The granules are ovate and many are characterized by a protuberance at one end. They vary in size to about 45 microns, long axis, and up to about 24 microns in width at the broad end. With polarized light the granules exhibit a distinct cross through the hilum at the small end.

Unscraped Ginger

In addition to the tissues described above, the following tissues are present in unscraped ginger: (a) epidermis, frequently disorganized, consisting of tangentially oblong-rectangular cells; (b) a hypodermis of a few layers of parenchymatous cells; and (c) several layers of tangentially oblong-rectangular, thin-walled, suberized cork cells.

Ground Ginger

The most important identifying characteristics of ground ginger are (a) the abundance of starch; (b) large vessels; and (c) fibers. The fibers of ginger are only partially lignified, but refractive to polarized light. With chlor-zinc-iodine they stain blue with varying intensity. In samples of *unscraped* ginger there will be seen, in addition to the above, fragments of cork, hypodermis, and epidermal cells.

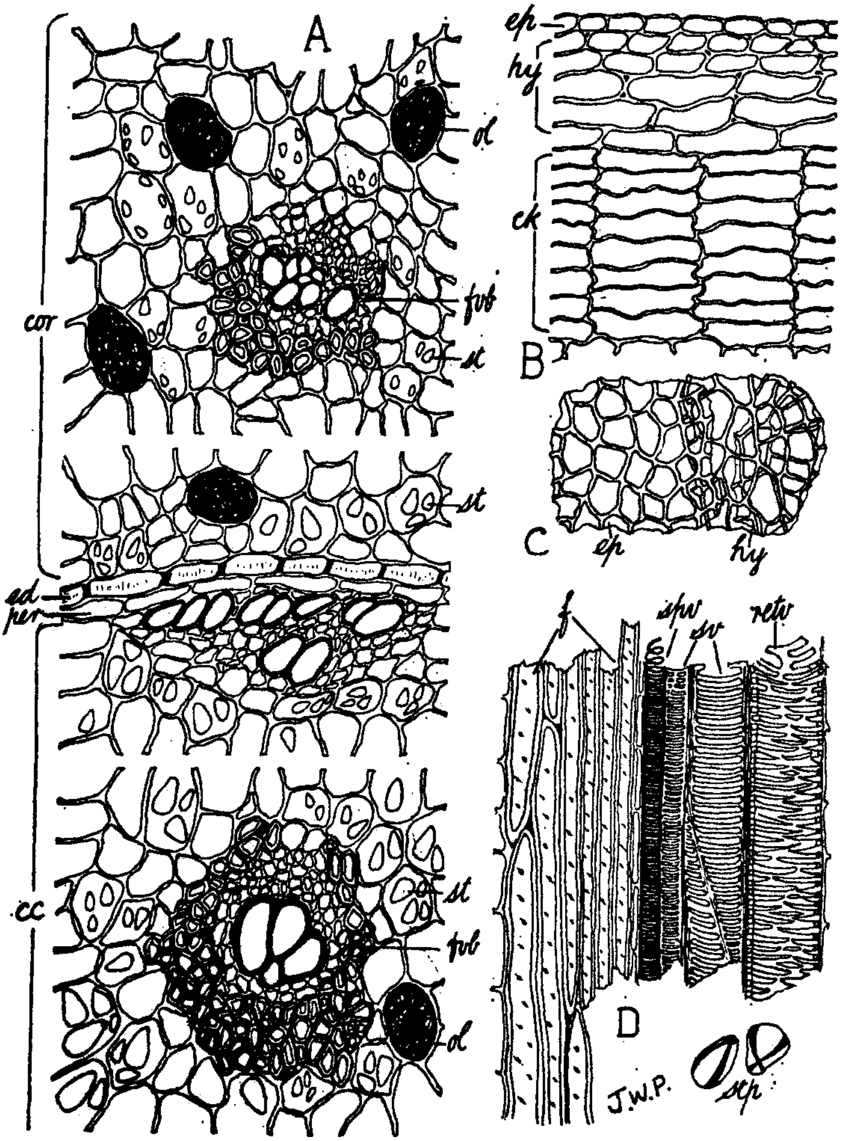

Fig. 8. GINGER. (A) Cross section of Jamaica ginger. (B) Cross section of outer tissues of unscraped ginger. (C) Surface view of epidermis and hypodermis, unscraped ginger. (D) Fibrovascular tissue.

cc, central cylinder; ck, cork; cor, cortex; ed, endodermis; ep, epidermis; f, fibers; fvb, fibrovascular bundle; hy, hypodermis; ol, oleoresin; per, pericycle, retv, reticulated vessel; sv, scalariform vessel; spv, spiral vessel; st starch; stp, starch, polarized light.

IX. MACE

Myristica fragrans Houtt

GENERAL

The mace of commerce is a product of the nutmeg tree. It is the crimson aril which clothes the shell-enclosed nutmeg. The aril is skilfully removed by opening it from the top and turning it back, after which it is flattened out either by hand or between boards. The mace is then placed in the sun for a few hours each day until dry.

Fresh mace is brilliant red in color, and somewhat tough and leathery. Drying changes the color to buff or light brown, and the mace becomes horny and brittle.

MORPHOLOGY

True Mace

This is the aril of the nutmeg seed. It must be differentiated from the aril of *Myristica argentea* War., known as Macassar or Papua mace, and from the aril of *Myristica malabarica* Lam., known as Bombay or Wild mace.

True mace, in the dried, or commercial state, is buff or very light-brown in color. It varies in length to about 4 cm, and consists of flat pieces, branched, smooth, horny and brittle.

The odor of true mace is fragrant and nutmeglike; the taste is aromatic and slightly warm.

Bombay or Wild Mace

This is reddish-brown in color. It is around 4 to 4.5 cm in length, and consists of numerous, narrow branches dividing to form a dense, almost solid, domelike mass of thin, curled branchlets at the apex.

Bombay mace is practically odorless and definitely tasteless. It is an adulterant.

True mace is usually marketed under the name of its place of origin, as, for example, Grenada, Penang, or Banda.

HISTOLOGY

Cross Section of Grenada Mace

In cross section Grenada mace (a true mace) consists of (a) cuticle; (b) an outer epidermis of irregular-shaped cells with thick walls; the outer walls are much thicker than the inner; (c) an hypodermis consisting of a layer of thick-walled cells, and, in places, one or more additional layers, similar in appearance to the epidermal cells. Where additional layers occur, the walls of these cells are much thinner than those of the cells of the main hypodermal layer. It should be observed that the hypodermis is not always a continuous layer, sometimes being broken or interrupted. The cell walls of the epidermis and those of the hypodermis stain pale blue with chlor-zinc-iodine following iodine-iodide solution; (d) a mesophyll consisting of thin-walled parenchyma cells containing amylodextrin granules, densely packed and staining brown with iodine solution; numerous large, oleoresin cells, yellow in color; vascular bundles consisting of xylem and phloem tissues. In longitudinal section,the vessels are mostly scalariform, with some reticulated and spiral vessels present; and, finally, an inner epidermis of thick-walled cells similar to those of the outer epidermis.

In surface view, the epidermis consists of greatly elongated cells with wide walls etched with very fine cross lines; the cells of the hypodermis are polygonal in shape.

Ground Mace

Ground mace in a water mount appears as a pasty mass in the microscope field, but when well rubbed out fragments of the tissues described above are clearly identifiable.

Presence of Bombay Mace

In cross section, the outer wall of the epidermal layer of Bombay mace is thicker than that of true mace. The epidermal cells of Bombay mace tend to radial elongation and lie close together, averaging around 8 cells to 100 microns, whereas those of true mace are irregular in shape and average around 4 or 5 cells to 100 microns. In surface view, the walls and lumens of the epidermal cells of Bombay mace are narrower than those of true mace. A hypodermis is ill-defined or absent in Bombay mace, but present for the most part in true mace. In surface views of fragments of mace consisting of epidermis and underlying tissues the hypodermis is obscure or absent in Bombay mace, but prominent in true mace. In such fragments, the oleoresin cells of Bombay mace will be seen to be more numerous and closely packed than those of true mace. In both products the oleoresin cells are more numerous in the outer mesophyll regions, but more particularly so in Bombay mace. The oleoresin cells of Bombay mace are a bright orange in color, but those of true mace are definitely yellow. On the addition of sodium hydroxide solution the oleoreisin cells of Bombay mace turn red, but the oleoresin cells of true mace remain yellow when similarly treated.

The presence of Bombay mace may be confirmed by the following chemical test. Prepare an alcoholic extract of the mace under examination. To the extract add a few drops of potassium chromate solution. If Bombay mace is present the precipitate and extract will turn red on standing. If Bombay mace is absent the precipitate and extract will be yellow and remain so on standing.

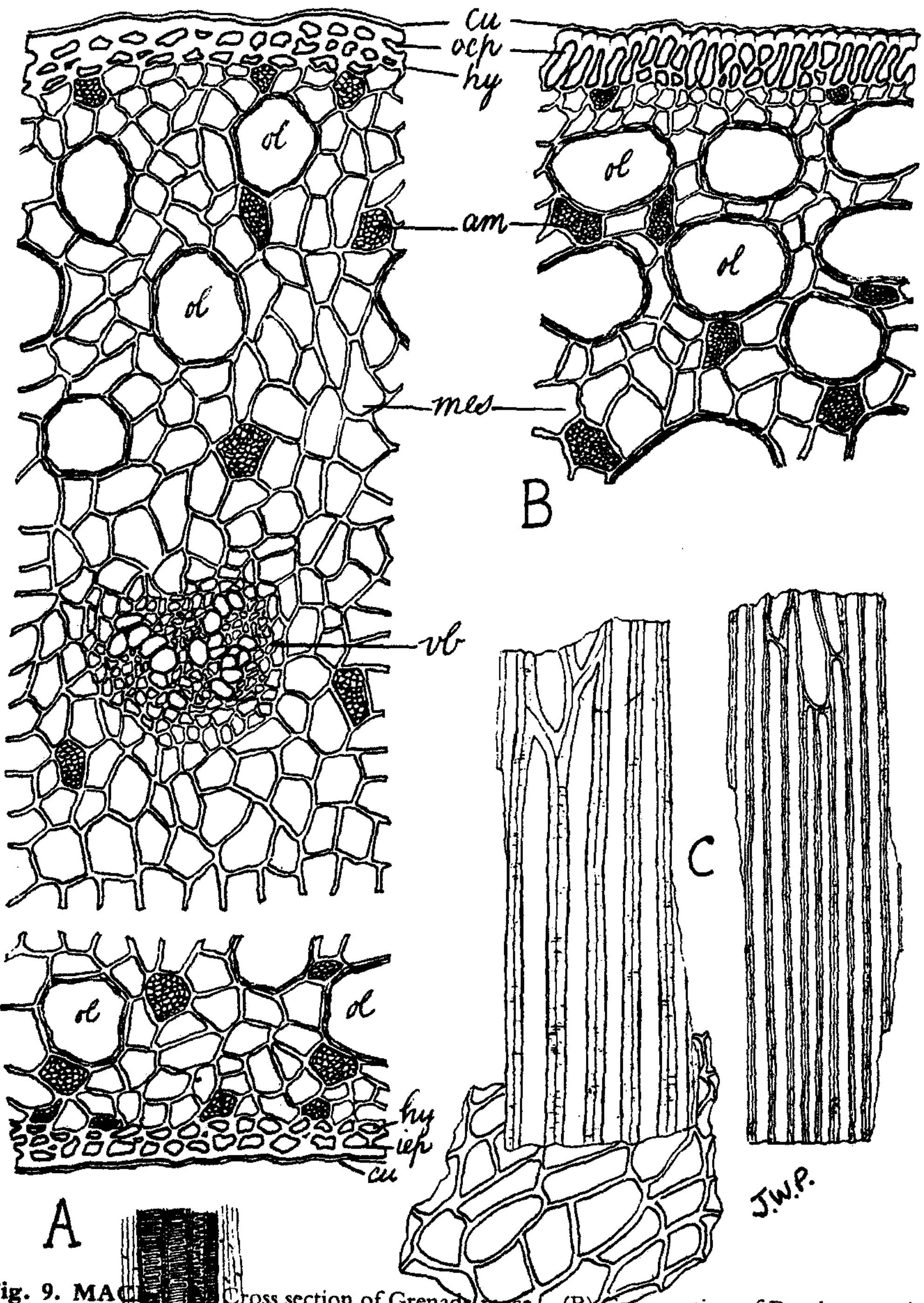

Fig. 9. MAC[illegible] Cross section of Grenada mace. (B) Cross section of Bombay mace. (C) Surface vi[illegible]rmis and hypodermis of Grenada mace (left); of epidermis of Bombay mace (right).

am, amylodextrin granules; cu, cuticle; hy, hypodermis; iep, inner epidermis; mes, mesophyll; oep, outer epidermis; ol, oleoresin cells; vb, vascular bundle.

X. NUTMEG

Myristica fragrans Houtt
Family: *Myristicaceae*

GENERAL

The nutmeg tree is bushy, and reaches about 30 to 40 feet in height. It is dioecious. The leaves are alternate, oblong-ovate, acute at apex and base, entire, coriaceous; dark green and lustrous on the upper surface, whitish on the lower; petiolate; and about 10 cm, or more, in length.

The flowers are small, fleshy, pale yellow, and aromatic. The staminate (male) and pistillate (female) flowers are borne on separate trees The staminate flowers are larger than the pistillate, axillary, usually in clusters of three.

The pistillate flowers are single, solitary, and axillary.

The fruit when ripe resembles a peach in appearance, and is yellow, smooth, and fleshy. It becomes dry and coriaceous and splits open disclosing a bright red, fleshy, laciniate aril which invests a thin, lustrous, deep brown shell containing a single seed or nutmeg.

In Penang the fruit is sometimes allowed to fall but it is usually collected from the trees with the aid of a bamboo stick about three feet long, split several times close to one end and expanded to form a bulbous cavity surmounted by a two-pronged projection. The nutmeg kernels are dried in the sun, and when, on shaking, the nutmegs rattle in the shells they are ready for storing. The nutmegs are later freed from the shells by cracking them open with a wooden truncheon, or by mechanical means.

In Grenada, British West Indies, the fruits are allowed to fall and it is considered unsound to "reap" them from the trees. The freshly fallen fruits are gathered each morning and carried to "boucans" or curing houses for processing. It requires from 6 to 8 weeks to cure the nutmegs in the air and sun.

Nutmegs are usually graded by weight, the three common grades averaging

65, 85, and 110 nutmegs per pound respectively, but are also exported unassorted.

MORPHOLOGY

Nutmegs are grayish-brown in color; mostly ovoid or ellipsoidal but some nearly globular in shape, and varying in size. The large ovoid nutmegs are around 30 mm in length and 20 mm in thickness. The surface is furrowed, wrinkled, with a raphe depression or groove extending from a scar at the base of the seed to a depression at the apex. Nutmegs are quite hard, yet cut easily. The cut surface presents a pale brown color (endosperm) marked by many brown veins (perisperm). It is in these veins that the essential oil of nutmeg is found, and pressure upon any one of them will cause an exudation of oil. When halved longitudinally the remains of the embryo are discernible.

Nutmegs have a characteristically aromatic odor, and an aromatic, warm, slightly bitter taste.

HISTOLOGY

In cross section, nutmeg consists of (a) an outer perisperm of tangentially elongated, thick-walled cells filled with reddish-brown pigment and containing prismatic crystals, probably acid potassium tartrate; small intercellular spaces; (b) an inner perisperm with arms branching into the endosperm, and consisting of isodiametric cells with reddish-brown contents, and, in those parts branching into the endosperm, numerous large oil cells; (c) vascular bundles of phloem and xylem tissue situated in the inner perisperm. The vessels are spiral; (d) a layer of compressed cells separating the inner perisperm from the endosperm; (e) an endosperm of polygonal parenchyma cells. Starch is the chief constituent of the endosperm cells. The starch granules are round or truncated, with central hilum, and from about 3 to 22 microns in diameter; with polarized light they exhibit a distinct cross. The endosperm appears whitish in the microscope field with occasional yellow-orange pigmented areas.

In surface view, the cells of the outer perisperm are isodiametric in shape. The crystals are clearly visible with ordinary transmitted light, and refractive to polarized light.

Embryo

The remains of the embryo may be removed from the seed by soaking the nutmeg in water and removing the surrounding tissues from the radicle and branched cotyledons. Noteworthy features of the embryo are the numerous oil cells and long, canal-like secretion cells, which, in the cotyledons, lie very close to, and almost surround, the vascular tissues. In the radicle there is similar structure but, in addition, there are numerous oil cells scattered throughout the parenchyma tissue. The vascular tissue is well developed, and spiral, reticulated, and scalariform vessels will be observed in the xylem.

Ground Nutmeg

Because of the large quantity of fixed oil in nutmeg, the ground sample in a water mount appears as a thick, pasty mass in the microscope field. It must be well rubbed out. Fragments of endosperm are predominant; other tissues to lesser degree. The starch is abundant and significant, being easily identified with ordinary transmitted light, and conspicuous with polarized light. The starch is seen in single granules, in groups of 2, 3 or 4 granules, and in large aggregates.

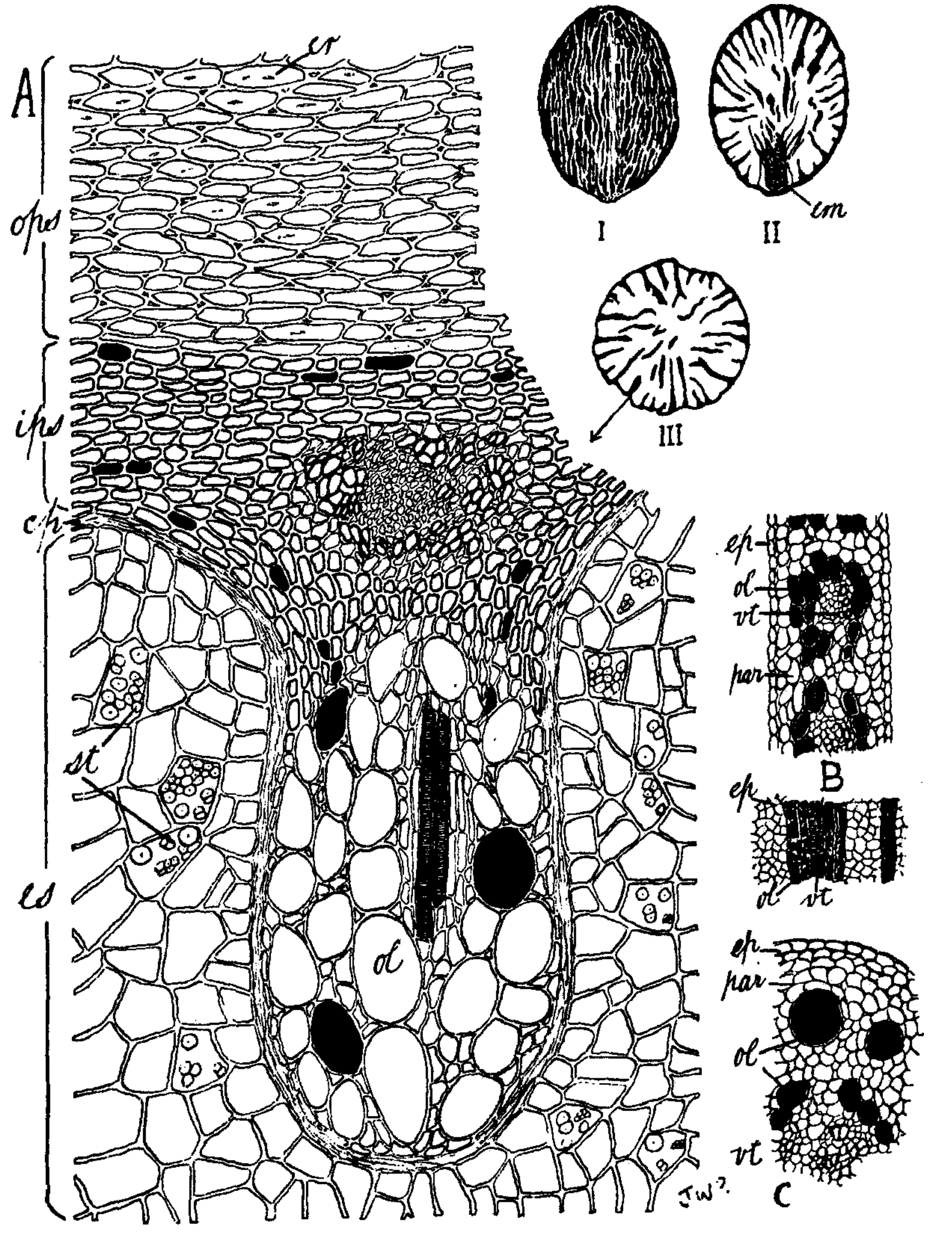

Fig. 10. NUTMEG. I—Whole nutmeg. II—Nutmeg, longitudinal section. III—Nutmeg, cross section. (A) Cross section through perisperm and endosperm. (B) Cotyledon, cross section (above); surface view (below). (C) Cross section of a portion of radicle.

cp, compressed parenchyma; cr, crystals; em, embryo; ep, epidermis; es, endosperm; ips, inner perisperm; ol, oleoresin cells; ops, outer perisperm; par, parenchyma; st, starch; vt, vascular tissue.

XI. PEPPER

Piper nigrum L.
Family: *Piperaceae*

GENERAL

The pepper plant is a perennial, climbing shrub or vine with a smooth, woody, articulate stem swollen at the joints. The vine clings to a tree or other support by means of numerous short rootlets produced at the joints of the stem. In its natural state the pepper vine may reach a height of 20 to 25 feet, but under cultivation it is usually kept down to 15 feet.

The leaves are alternate, broad-ovate, accuminate, coriaceous, smooth, petiolate, and dark green.

The flowers are very small, whitish, sessile, and borne in pendulous, dense catkin-like spikes.

The fruit is small, berry-like, containing a single seed, sessile, nearly globular; at first green, then yellowish, and finally red when ripe.

When the berries begin to turn red the spikes are gathered from the pepper vines. The berries are removed from the spikes by hand or by beating with short sticks. The stalks or stems are separated from the berries by winnowing. The quality of the berries is said to be improved if they are next plunged into boiling water. Ten minutes of this treatment has the effect of turning the berries black in an hour. Drying is then carried out by spreading the berries on mats in the full sun, and is completed in about 3 to 4 days.

White pepper is obtained by depriving the pepper berries of the greater part of the pericarp, or outer coating as it is commonly called. This is accomplished by keeping the ripe berries for 2 or 3 days in moist heaps, or in sacks submerged in running water. This process softens the dark-colored pericarp which is then almost entirely removed by washing the berries in baskets, or by trampling them in a tub or tank followed by washing. The white berries are then spread out on mats and allowed to dry in the sun.

MORPHOLOGY

Black Pepper

Its berries or peppercorns are dark brown to black in color; nearly globular in shape; around 5 mm or less in diameter; with deep-set wrinkles forming a characteristic network. The pericarp is thin and encloses a single seed with a hollow center. The perisperm of the seed is horny in the outer part, floury around the central cavity. The embryo is embedded in a small endosperm at the apex of the seed.

Black pepper has a characteristic, penetrating, aromatic odor; and a hot, biting, very pungent taste.

White Pepper

Its berries are light yellowish-gray in color; nearly globular in shape; around 5 mm or less in diameter; smooth; striated; with a small protuberance at the base and another arising from a depression at the apex. The striations are very distinct on some berries, indistinct or not visible on others; they are vascular bundles.

The odor and taste of white pepper is similar to that of black pepper but less pungent.

HISTOLOGY

In cross section, the black pepper berry consists of the following tissues:

Pericarp

This consists of: (a) an exocarp of nearly rectangular cells and a well defined cuticle. In surface view the cells of the exocarp are polygonal, darkly pigmented, and contain small prismatic crystals. Occasional stomata will be observed; (b) hypodermis of stone cells interspersed in places with thin-walled polygonal cells. The stone cells of this supporting tissue are varied in shape but the greater number are radially elongated; (c) an outer mesocarp of moderately thick-walled, irregularly-shaped parenchyma cells, and scattered oleoresin cells; (d) a vascular bundle zone; (e) an inner mesocarp of sclerenchymatous cells irregular to tangentially elliptical in shape. These cells are smaller and the walls are thicker than those of the outer mesocarp; (f) a zone of sclerenchymatous cells varying in shape from isodiametric to tangentially oval or elliptical, and in size to about 85 microns, long axis, containing oil drops; (g) a layer of sclerenchymatous, porous (beaded) cells; and (h) an endocarp consisting of a layer of sclerenchymatous cells with thickened radial walls and very thick inner walls, commonly called "beaker cells."

At the base of the berry the walls of the various tissues are generally much thicker than elsewhere in the fruit; many walls are irregularly thickened, some are beaded. Stone cells are present. Here, the endocarp beaker cells modify and converge with other tissues, the inner cuticles terminate, and the vascular tissues enter the fruit.

The xylem tissues of the berry consist of xylem parenchyma, annular, and spiral vessels.

With chlor-zinc-iodine following bleaching, the cuticle, hypodermis, and all tissues from the vascular bundle zone to the endocarp inclusive stain yellow, indicating, with the exception of the cuticle, their sclerenchymatous nature (cuticle always stains yellow with chlor-zinc-iodine). If the section is left too long in the bleaching solution the lignin in the cell walls of the latter group of tissues will dissolve and the cell walls will stain blue (cellulose).

Seed

The tissues of the seed are (a) a thin cuticle; (b) seed coat consisting of an outer layer, connective layer, and inner layer of tangentially oblong or elliptical cells. Longitudinally, the cells of the outer layer are oblong; those of the connective layer, polygonal; and those of the inner layer, elongated; the latter with beaded walls. The cells of the outer and inner layers are darkly pigmented. At the apex of the seed the cells of the outer layer become isodiametric in shape, those of the connective layer are disintegrated, and those of the inner layer become palisade in shape. At the base of the seed, the seed coat thickens into a mass of darkly pigmented cells about 75 microns deep; (c) a thick cuticle which wrinkles severely in the apex region; and (d) the perisperm, consisting of an outer layer of polygonal cells containing aleurone grains, and inner layers of polygonal cells, varying in size to about 110 microns, long axis, containing masses of starch granules. Occasional oleoresin cells occur in the perisperm. Prismatic crystals occur scattered in the perisperm.

In the seed, the cuticles stain yellow, the seed coat blue, the aleurone layer brown and the starchy perisperm blue.

Endosperm and Embryo

The endosperm and embryo must be studied in longitudinal section. They are usually seen as a disorganized mass of tissue, but repeated sectioning and prolonged study will bring to view the small, polygonal parenchyma cells of the endosperm and the inner parenchyma cells of the embryo. These are not significant in a microscopical examination of ground pepper.

Ground Pepper

Fragments of the tissues just described will be observed in the microscope field of ground black pepper. The presence of blackish-brown fragments of the exocarp, and the stone cells of the hypodermis distinguish black from white pepper. In the fields of both peppers the sclerenchymatized beaker cells of the endocarp and the large masses of starch are prominent. Pepper starch is seen in the microscope field as irregular-shaped masses, with individual granules scattered about. Individual granules are very small, varying in size from about 2 to 6 microns with the majority of granules being from 3 to 4 microns. The shape is polyhedral; the hilum is central and visible with the high power of the microscope and subdued, transmitted light. With high power and polarized light a cross is faintly visible.

Related Pepper

Long Pepper. Long pepper is the compound fruit of two species of the pepper family—namely, *Piper officinarum* C. DC. and *Piper longum* L. The former is cultivated chiefly in Java, the latter in Bengal. The fruits of both species are elongated, cylindrical, catkin-like spikes of immature individual fruits fused together in spirals. The compound fruits vary in size from about 2 to 6 cm in length, and from about 4 to 8 mm in breadth. The color is grayish-black masking a reddish-brown visible after washing. The odor is aromatic; the taste is aromatic and pungent.

The principal histological features of the pericarp are an epicarp of polygonal-shaped cells similar to those of the epicarp of black pepper; a hypodermis with elongated stone cells; a mesocarp with a fibro-vascular bundle zone, volatile oil secretion cells, and reticulated palisade-like cells adjoining the endocarp; an endocarp of elongated, porous, sclerenchymatous cells. Because the small, individual fruits are coalesced, the epicarp and hypodermis exist only in the outer side of the fruit. The chief features of the seed are the sclerenchymatous outer layer of the seed coat, the elongated cells of the perisperm, and the presence of starch grains larger than those of black pepper.

Long pepper was employed as a spice from ancient to early modern times in Europe when its use rapidly dwindled. It is not important today and is probably employed more in southeast Asia than other parts of the world.

Cubebs. The cubeb is the fruit of *Piper cubeba* L. fil. It is a nearly globular fruit similar in size to black pepper. The base of the pericarp is extended into a pedicel-like formation. The surface is coarsely reticulated and brownish in color. Usually the seed is free from the pericarp except for a weak attachment at the base of the pericarp or, not infrequently, to some part of the pericarp other than the base. The odor is aromatic; the taste is aromatic and pungent

The principal histological features of the pericarp are an epicarp of thick, wavy-walled cells; an hypodermis of rectangular or polygonal, porous, thick-walled stone cells with intervening parenchyma tissue; an outer mesocarp of parenchyma tissue and numerous volatile oil secretion cells; an inner mesocarp of tangential, somewhat compressed parenchyma cells traversed by fibrovascular tissues; and an endocarp of isodiametric to radially oblong stone cells with thick, porous walls. The chief features of the seed are the parenchymatous seed coat; a perisperm of polygonal-shaped cells; a small endosperm; and a minute embryo. The individual starch grains are larger than those of black pepper.

Cubebs find some use in medicine but none in the spice trade.

African Black Pepper, Nigerian Black Pepper, African Cubebs. This pepper is the dried fruit of *Piper clusii* C. DC. The fruit is nearly globular with the base of the pericarp extended into a pedicel-like structure up to about 8 mm in length. The surface is rough, and the color varies from light to dark-brown. The size of the fruits vary from about 2 to 5 mm in diameter. The seed is firmly attached to the pericarp. The odor is aromatic; the taste is aromatic and pungent. Many pieces of stem are present, some with fruits attached, in a sample of this pepper.

The principal histological features of the pericarp are an epicarp of small, polygonal-shaped cells with occasional stomata; an outer mesocarp of parenchyma tissue in which many oleoresin cells occur; a central mesocarp of about seven layers of tangentially elongated parenchyma cells traversed by vascular tissues; an inner mesocarp of parenchymatous tissue with numerous large oil cells; and a parenchymatous endocarp. There are no stone cells in the pericarp. The chief features of the seed are the seed coat of three layers of compressed parenchyma cells with the outer walls of the outer layer being thickly cutinized; a perisperm of poygonal-shaped cells containing masses of starch; a small, parenchymatous endosperm in which is embedded a minute embryo composed of tiny parenchyma cells with a number of small oil cells occurring toward the radicle.

The pedicel-like structure at the base of the pericarp consists of an epidermis, a parenchymatous cortex in which many oleoresin cells occur in the outer region, a complete ring of fibro-vascular tissue, and a central region of thick-walled parenchyma cells.

The stem consists of an epidermis of very small cells with many multicel-

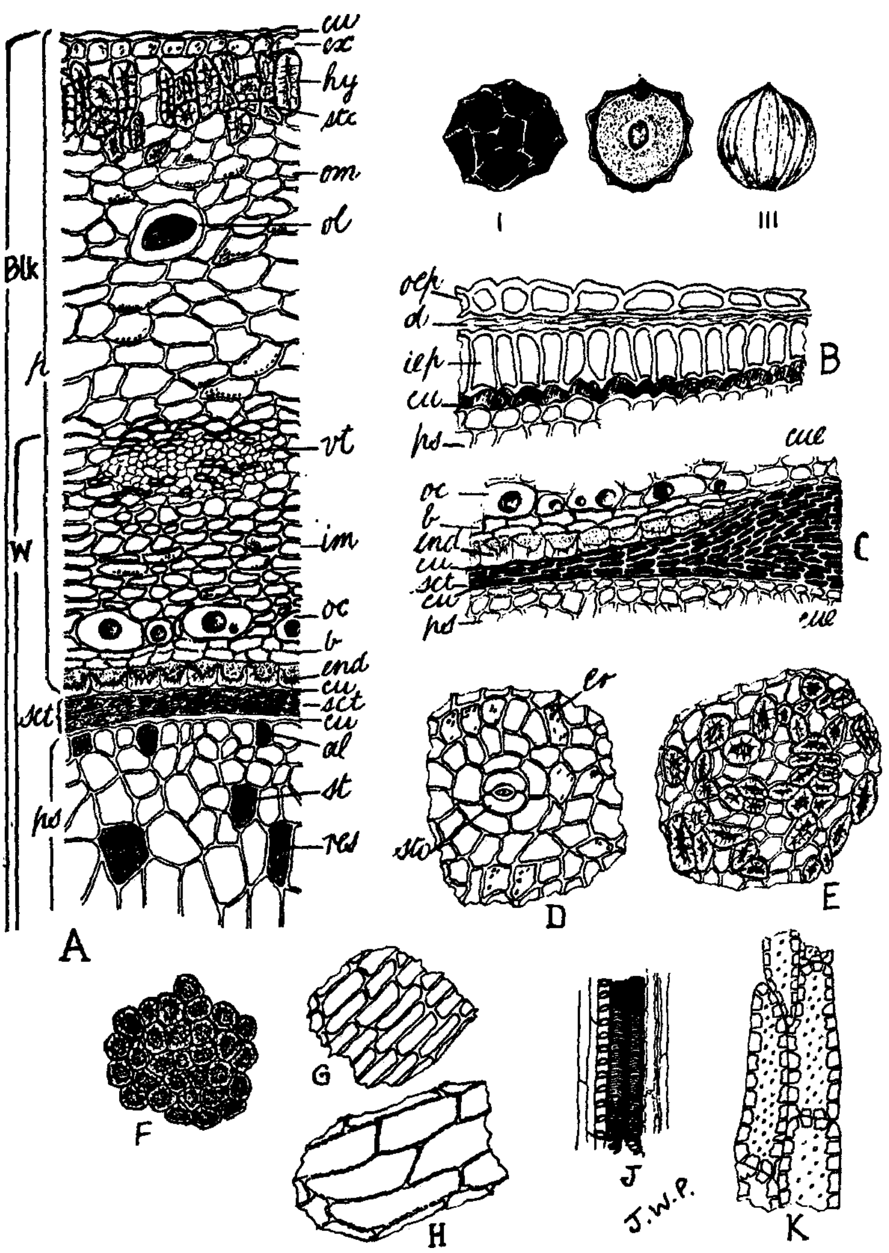

Fig. 11. PEPPER. I—Black pepper. II—Black pepper, cross section. III—White pepper. (A) Pericarp, seed coat, and portion of perisperm; Blk, black pepper; W white pepper. (B) Seed coat in apex region. (C) Seed coat in base region. [A,B, and C, in cross section.] (D) Exocarp. (E) Hypodermis. (F) Endocarp. (G) Outer epidermis of seed coat. (H) Inner epidermis (inner layer) of seed coat. [D, E, F, G, and H, in surface view.] (J) Vascular tissue. (K) Sclerenchymatous cells occurring in base region of pericarp.

al, aleurone; b, beaded cells; cr, crystals; cu, cuticle; cue, cuticle ends (terminates); d, disintegrated cells; end, endocarp; ex, exocarp; hy, hypodermis; iep, inner epidermis (inner layer of seed coat); im, inner mesocarp; oc, oil cells; oep, outer epidermis; ol, oleoresin; om, outer mesocarp; p, pericarp; ps, perisperm; res, resin; sct, seed coat; st, starch; stc, stone cells; sto, stoma; vt, vascular tissue.

lular, thin-walled, pointed hairs; a parenchymatous cortex; and a ring of fibro-vasuclar tissues. The central (pith) region is hollow.

This pepper is employed in Africa as a spice.

XII. SAFFRON

Crocus sativus L.
Family: *Iridaceae*

GENERAL

A perennial, low-growing plant with an underground globular corm. Leaves radical, sheathing, sessile, linear, dark green on the upper surface with a central, longitudinal, white line or furrow, paler on the under surface.

Flowers borne on a scape, blooming in the autumn. Perianth pale reddish-purple, with a cylindrical tube and 6 oblong-oval segments. Stamens 3; ovary inferior and 3-loculed. Style slender, elongated, pale yellow, and terminating in 3 drooping, deep red stigmas.

Only the stigmas are employed in the spice trade.

MORPHOLOGY

Dried stigmas, 3 in number surmounting a short length of style, or free. Stigmas dark red, convoluted, trumpet-shaped, scalloped or notched at the distal end, usually about 25 mm long. Style yellowish.

Odor strong, suggestive of iodine, unpleasant, aromatic; taste aromatic, bitter.

HISTOLOGY

The cells of the stigmas are elongated, narrow, thin-walled, and contain coloring matter. Short papillae are a characteristic of the epidermal cells. Long papillae, varying in length to 150 microns and in width to about 45 microns, occur at the distal ends of the stigmas. Phloem, and xylem tissue with delicate annular and spiral vessels complete the tissue.

Spherical pollen grains up to about 120 microns in diameter are usually present among the long papillae.

XIII. MEXICAN OR AMERICAN SAFFRON

Carthamus tinctorius L.
Family: *Compositae*

GENERAL

An annual herb grown in the temperate regions of the central Mexican tablelands. The plant reaches about 1 foot or more in height. It has an erect stem, somewhat branched at the top, ovate-oblong leaves, and orange-colored flowers.

MORPHOLOGY

Tubular florets, deep orange-red in color, from about 2.5 to 4 cm in length; corolla gamopetalous, cylindrical, with 5 narrow lobes; stamens 5, arising from the corolla tube, anthers encircling the style; style bilobed, yellow.

Odor strong, unpleasant, sweetish and aromatic; taste aromatic, bitter.

HISTOLOGY

Corolla

In surface view, the epidermal cells of the corolla tube are nearly oblong-rectangular in shape and straight-walled. Those of the corolla lobes are elongated and have sinuous walls, except at the apexes where the cells are small and papillose. A few papillae of moderate length occur on the outer epidermis near the apexes of the lobes. Numerous prismatic crystals of calcium oxalate are present in the apex cells. Five vascular bundles and 5 oil canals traverse the mesophyll of the corolla tube. Where the lobes begin these bundles and canals branch and traverse the marginal mesophyll of the lobes.

Stamens

In surface view, the epidermal cells of the filament are small, thin-walled and oblong-rectangular. A few multicellular, multiseriate hairs occur near the juncture of filament and anther. A single vascular bundle containing delicate spiral vessels traverses the filament.

The epidermal cells toward the base of the anther are oblong-rectangular to nearly quadrilateral in shape and have strong but not thick walls. Toward the apex of the anther the cells bordering the dehiscent tissue and extending to the margins and apex of the anther are thick-walled and porous. In the region of dehiscence the cells are oblong-rectangular and thin-walled. The pollen grains are spherical, spinose, and up to 50 microns in diameter.

Style and Stigma

In surface view, the epidermal cells of the style are oblong-rectangular and thin-walled. A fibrovascular bundle and 2 oil canals traverse the style; they branch and traverse the lobes of the stigma. The fibers are long, narrow, and of cellulose.

The stigmatic surface is bristling with spinose papillae up to 180 microns long at the bulbous base of the stigma and becoming progressively shorter toward the apexes of the lobes; at the apexes the papillae are very small. Pollen grains are usually present among the papillae, many germinated and exhibiting pollen tubes.

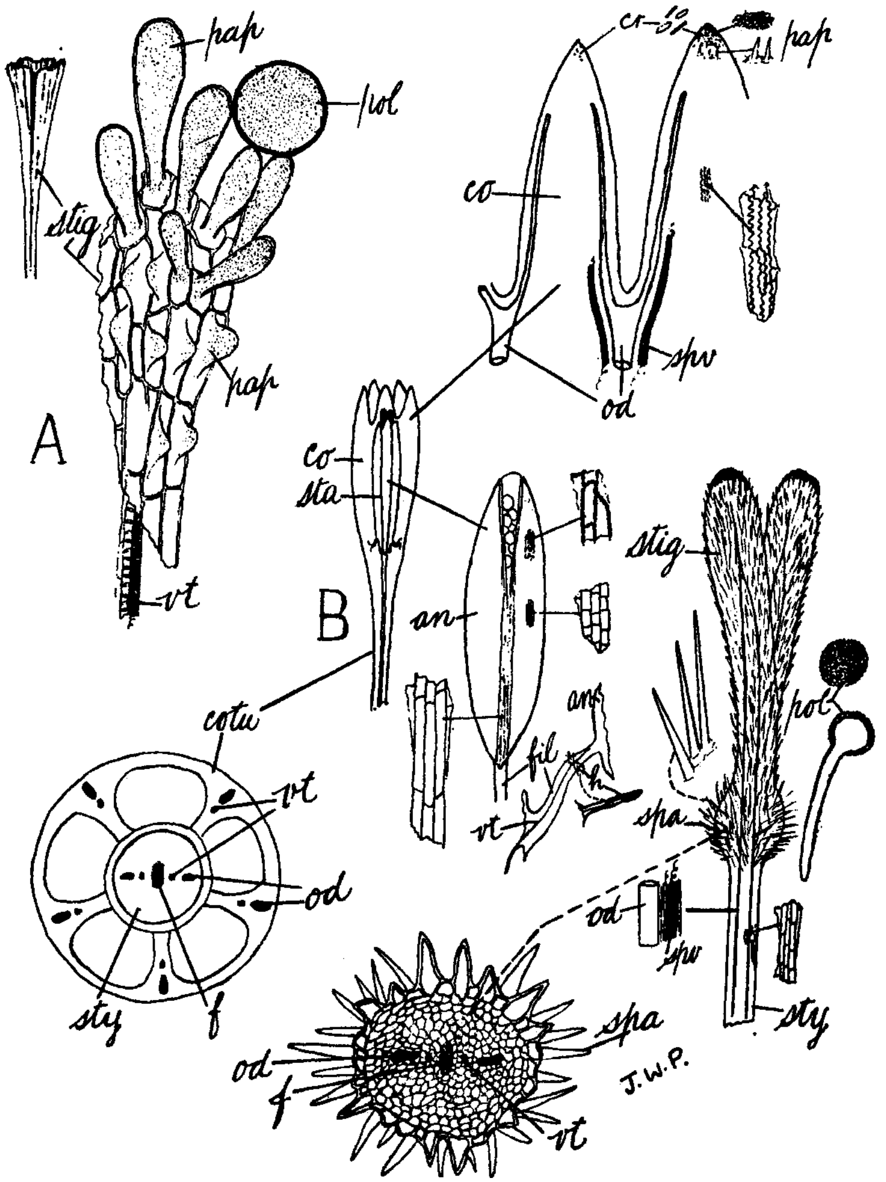

Fig. 12. SAFFRON. (A) True saffron. (B) Mexican saffron (safflower).

an, anther; co, corolla; cotu, corolla tube; cr, crystals; f, fibers; fil, filament; h, hair; od, oil duct; pap, papilla; pol, pollen; spa, spinose papilla; spv, spiral vessel; sta, stamen; stig, stigma; sty, style; vt, vascular tissue.

XIV. STAR ANISE

Illicium verum Hook
Family: *Magnoliaceae*

GENERAL

An evergreen tree reaching a height of about 18 feet. Leaves elliptical to oblanceolate, glandular-punctate, entire, acute. Flowers greenish-yellow, axillary. Fruit consisting of a number of woody follicles or carpels arranged around a central axis, each carpel containing a single seed.

MORPHOLOGY

Fruit whorl from 2.5 to 4.5 cm in diameter, individual carpels from about 9 to 19 mm in length; surmounted on a curved peduncle; carpels laterally broad and flat where they join the central axis, bellied and tapered to a point; boat-shaped. Carpels hard, woody, wrinkled, rough, rigid, reddish-brown; internally smooth, lustrous and light brown. Seed light brown, compressed ovoid, about 8 to 9 mm long, 6 mm broad; smooth, lustrous, with conspicuous hilum scar and raphe ridge. Seed coat brittle; endosperm bulky; embryo disorganized.

The carpels of star anise have a pleasant, anise-like odor, and an agreeable, aromatic, sweet, anise-like taste; the seeds to a lesser extent.

HISTOLOGY

Pericarp

Cross section.

Exocarp. Consisting of cuticle and a layer of epidermal cells with thick outer walls, up to 20 microns in places.

In surface view, the cuticle is striated. The epidermal cells are polygonal in shape, and vary in size to about 133 microns, long axis. Stomata are present but not numerous.

Mesocarp. Consisting of parenchyma cells, isodiametric in shape or nearly so, with brown contents. The cells increase in size toward the central zone of the mesocarp, where they reach about 220 microns, and decrease toward the endocarp. The walls of the inner mesocarp cells are thicker than those of the central mesocarp cells, increase in thickness toward the dehiscent side of the carpel, and in the dehiscent zone adjoining the endocarp the cells pass into lignified fibers; in longitudinal section these fibers are long and pitted.

Resin cells and irregular-shaped stone cells are scattered throughout the mesocarp. The resin cells vary in size to about 220 microns, long axis, and contain yellow to brownish-yellow oleoresin. The stone cells vary in size and thickness and are noteworthy for their branching and irregularity.

Vascular bundles occur in the merging zone of the central and inner mesocarp, and consist of phloem tissue and spiral, scalariform, and scalariform-reticulate vessels.

Endocarp. Consisting of a layer of thin-walled, sclerenchymatous palisade cells up to about 440 microns, long axis, decreasing in size toward, and becoming stone cells in the dehiscent region.

In surface view, the thin-walled cells are polygonal in shape, and vary in size to about 120 microns, long axis, most of the cells being around 90 to 100 microns.

Seed

Cross section.

Seed Coat. Consisting of (a) an epidermis of thick-walled, sclerenchymatous, pitted palisade cells up to about 200 microns, long axis; (b) 5 layers of sclerenchyma cells; and (c) 2 or more layers of thin-walled parenchyma cells containing numerous prismatic crystals of calcium oxalate.

In surface view, the epidermal cells are up to about 66 microns, long axis, and show considerable thickening with branching pits. The sclerenchyma tissue can be divided into 3 layers of irregular-shaped cells on the outer side, and 2 layers of elongated, narrow cells on the inner.

Endosperm. Consisting of polygonal cells varying in size to about 110 microns, long axis, and containing aleurone grains and globules of fixed oil.

The aleurone grains are large and each contains a correspondingly large crystalloid; globoids also occur.

Embryo. The tissue is disorganized.

Peduncle

In cross section consisting of (a) striated cuticle; (b) a layer of epidermal cells with thick outer walls; (c) cortex consisting of parenchyma cells varying in size to about 155 microns, long axis, oleoresin cells to about 90 microns, and branching stone cells varying greatly in shape and size; (d) a ring of fibrovascular tissue; and (e) pith with isodiametric cells varying in size to about 155 microns.

Receptacle

The *receptacle* or *central axis* is anatomically similar to the peduncle but branching stone cells, and pitted cells, are more abundant.

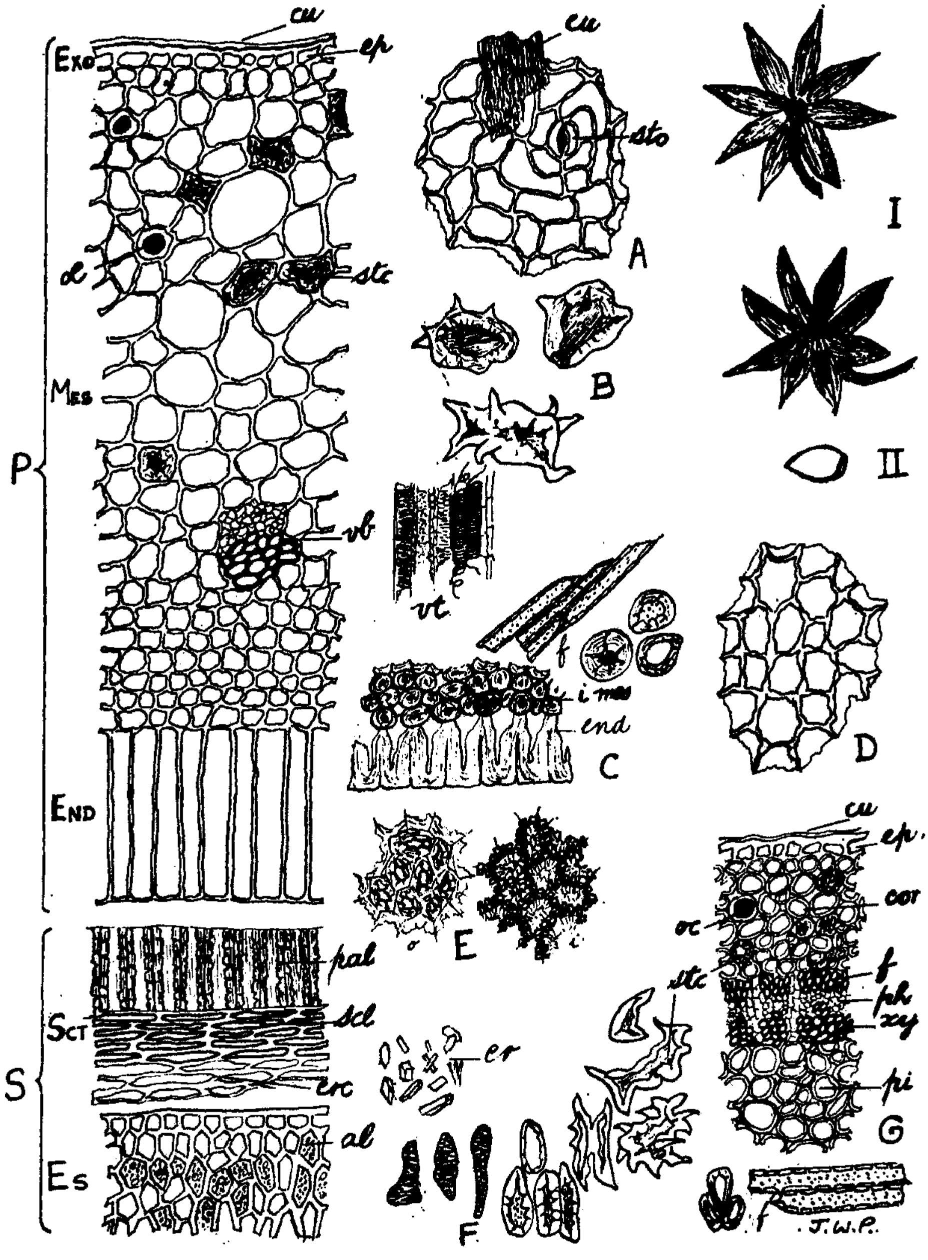

Fig. 13. STAR ANISE. I—Fruit. II—Seed. (P) Cross section of pericarp. (S) Cross section of seed. (A) Epidermis of pericarp in surface view. (B) Stone cells of pericarp. (C) Inner mesocarp and endocarp at dehiscent edge of carpel. (D) Endocarp in surface view. (E) Outer and inner (o and i) surface views of palisade cells of seed coat. (F) Reticulated cells and stone cells occurring in the region of the raphe. (G) Cross section of peduncle.

Al, aleurone; cor, cortex; cr, crystals; crc, crystal cells; cu, cuticle; end, endocarp; ep, epidermis; es, endosperm; exo, exocarp; f, fibers; i.mes, innermesocarp; mes, mesocarp; oc, oil cell; ol, oleoresin; pal, palisade cells; ph, phloem; pi, pith; scl, sclerenchyma cells; sct, seed coat; stc, stone cells; sto, stoma; vb, vascular bundle; vt, vascular tissue; xy, xylem.

XIV. TURMERIC

Genus: *Curcuma longa* L.
Family: *Zingberaceae*

GENERAL

An herbaceous plant with a perennial rootstock or rhizome from which arises tufts of large, broad, lanceolate, bright green leaves, acute at both ends, reaching 2 to 3 feet in height.

Flowers yellow or pale-yellow, borne in a spike terminating a stem shorter than the leaves. The flowers arise from 2 buds situated in the axils of bracts, and mature successively. Bracts are greenish-white, the uppermost tinged with pink.

When the rhizomes are harvested they are first washed to free them from adhering earth, and then cured by placing them in earthenware or metal pots to which is added a few of the dried leaves of the turmeric plant and just enough water to cover the rhizomes. The pots are covered and placed over a slow fire for about three hours and then allowed to cool. Following this process, the rhizomes are spread in the sun to dry for 5 to 7 days. It is customary to polish the dried rhizomes in some manner, usually by rotating them in a horizontally mounted cylinder for a period of ten minutes.

MORPHOLOGY

Alleppey Turmeric

The rhizomes are deep-yellow to orange-yellow in color, and from about 2.5 to 7.5 cm in length, from about 7 to 15 mm in thickness; almost cylindrical, curved, and tapering at the ends; palmate (known as fingers); with tubercle-like protuberances; or plainly cylindrical but thicker toward one end (known as bulbs). Rhizomes are rough, hard, and with numerous encircling ridge-like rings or annulations. When fractured, the break is clean, not splintery or fibrous; surface waxy or horny and resinous in appearance. On the fractured surface the endodermis is clearly visible separating the cortex from the central cylinder.

Turmeric has a characteristic pepperlike odor, and a slightly aromatic, somewhat bitter taste.

Madras Turmeric

The rhizomes are mustard-yellow in color. Similar in other respects to the Alleppey product.

Haiti Turmeric

The rhizomes are a dull yellowish-brown in color; mostly small; of poor appearance; product usually includes broken pieces and longitudinally split rhizomes; otherwise similar to the Indian turmeric.

HISTOLOGY

Cross section of rhizome:

Epidermis

This consists of a layer of tangentially oblong-rectangular cells with occasional unicellular, nonglandular, thick-walled hairs.

Hypodermis

This consists of two or three layers of irregular-shaped parenchymatous cells.

Cork

This consists of about six layers of tangentially oblong-rectangular cells arranged in orderly radial rows.

Cortex

This consists of (a) thin-walled parenchyma cells containing starch; (b) oleoresin cells; and (c) vascular bundles.

Endodermis

This is a layer of tangentially oblong-rectangular cells with thickened radial walls; globules of oil are present in these cells.

Pericycle

This is a layer of tangentially oblong-rectangular cells adjoining the endodermis on the inner side.

Central Cylinder

This consists of (a) vascular bundle zone adjoining the pericycle; (b) parenchyma cells containing starch; (c) oleoresin cells; and (d) vascular bundles scattered in the central tissue region.

The vascular tissue of turmeric consists of phloem and xylem; there are no fibers. The vessels are spiral or scalariform.

Epidermis in Surface View

The cells of the epidermis are polygonal in shape, vary in size to about 120 microns, long axis, and have moderately thick, beaded walls. The beading is best observed in cleared tissue with powers from ×250 to ×500. The epidermis may be cleared with the aid of chloral hydrate, or decolored with bleaching solution. It should then be treated with nitric acid to dissolve the crystalline matter in the cells. Very small prismatic crystals, and groups or masses of crystals without definite shape occur in the epidermal cells.

A few stomata occur in some parts of the epidermis. They are about 30 microns, long axis, with stomatal opening from about 18 to 22 microns. Each stoma is surrounded by 4 epidermal cells.

The hairs are mostly straight, pointed, unicellular, with moderately thick walls. They vary in length to about 600 microns, and in basal width from about 30 to 50 microns. The hairs are fairly numerous but they are not distributed evenly, more occurring in some areas than in others (as with the stomata).

Starch

During the scalding or boiling process used in the preparation of this spice for market almost all of the starch granules are partially cooked leaving them without uniform characteristics. The granules may be whole or fragmented; they are irregular in shape, and they exhibit degrees of shell-like markings. Undamaged starch granules are similar to those of ginger. Turmeric starch is usually seen in the microscope field as irregular-shaped masses or lumps stained yellow with curcumin. On the addition of a drop of iodine test solution these lumps turn dark blue, identifying them as starch.

Ground Turmeric

The most important identifying characteristics of ground turmeric are

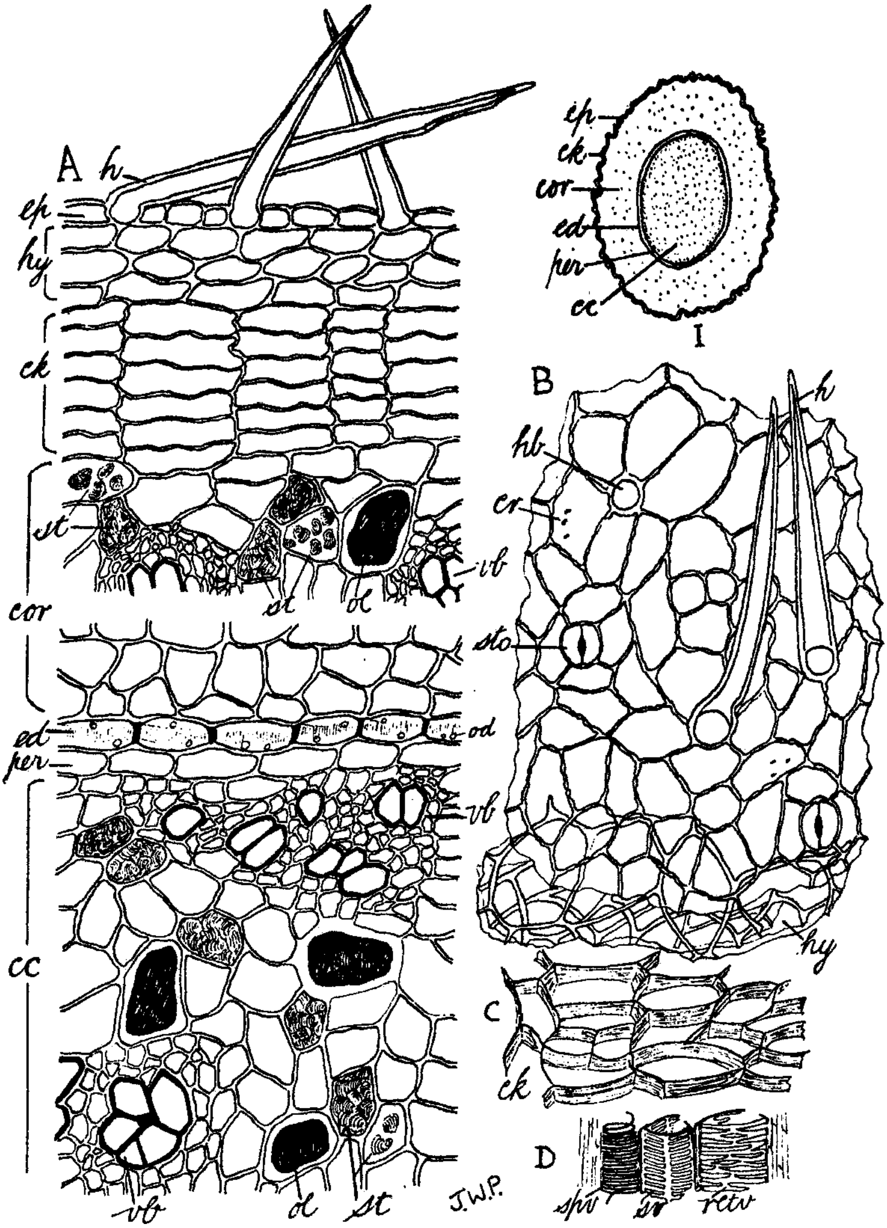

Fig. 14. TURMERIC. I—Whole rhizome, cross section. (A) Cross section to central cylinder of rhizome. (B) Surface view of epidermis and hypodermis. (C) Surface view of cork cells.—(D) Vascular tissue.

cc, central cylinder; ck, cork; cor, cortex; cr, crystals; ed, endodermis; ep, epidermis; h, hair; hb, hair base; hy, hypodermis; od, oil drops; ol, oleoresin; per, pericycle; retv, reticulated vessel; sv, scalariform vessel; spv, spiral vessel; st, starch; sto, stoma; vb, vascular bundle.

(a) numerous irregular-shaped, shell-like, yellow starch lumps; (b) oleoresin lumps, which appear dark, smooth and shiny; (c) fragments of cork cells, and abundant parenchyma tissue; and (d) large, spiral and scalariform vessels of the xylem.

Miscellaneous Seeds

XVI. FENUGREEK

Trigonella foenum-graecum L.
Family: *Leguminosae*

GENERAL

This is an annual herb reaching a height of about 2 feet. Leaves light green, pinnately trifoliate; leaflets obovate. Flowers papilionaceous, small, white. Fruit a legume, long, narrow, curved, tapering into a slender point, and containing small, deeply furrowed seeds.

MORPHOLOGY

Seed yellowish-brown, 2.5 to 5 mm long, 2 to 3.5 mm broad; oblong-rhomboidal, with a deep furrow running obliquely from one side dividing the seed into a larger and smaller part; smooth, and very hard, hilum in the notch, short raphe; translucent endosperm; yellow embryo, with cotyledons occupying the larger part of the seed and the radicle the smaller. Seed becomes coated with mucilage when soaked in water.

Fenugreek has a strong, pleasant, sweetish odor reminiscent of that of burnt sugar. The taste is decidedly farinaceous and slightly bitter.

HISTOLOGY

Seed

Cross section.

Seed Coat. This consists of: (a) cuticle; (b) a layer of thick-walled columnar or palisade cells, flat at the base, mostly pointed but some flattened at the apex, from about 65 to 70 microns high, and 8 to 20 microns wide, with conspicuous light line about 22 microns from the outer end; (c) a layer of supporting or bearer cells, low, tangentially wide, with radial rib-like thickening; and (d) 4 or 5 layers of tangentially elongated, thin-walled parenchyma cells.

In surface view, with low power, the palisade layer appears as a mass of very small, papillose-like cells; with higher power, focused down, the cells are polygonal with pitted thickening. The bearer cells are polygonal but the thickening causes them to appear isodiametric or elliptical; they vary in size up to about 85 microns, diameter or long axis.

Endosperm. This consists of: (a) a layer of thick-walled cells containing aleurone grains; and (b) several layers of thin-walled, mucilaginous cells varying in size to about 250 microns, long axis, radially elongated in the outer, and tangentially elongated in the inner endosperm.

In surface view, the aleurone cells are polygonal in shape, and vary in size up to about 45 microns, long axis.

Embryo. In cross section, the radicle consists of a layer of small epidermal cells; several layers of isodiametric, or nearly so, parenchyma cells varying in size up to about 50 microns, and a central core or zone of very small isodiametric cells varying in size to about 18 microns. The cotyledons consist of (a) an upper and lower epidermis of small cells; (b) mesophyll of 3 to 4 layers of palisade cells varying in size up to about 80 microns, long axis, and several layers of rudimentary spongy tissue; and (c) rudimentary vascular tissue situated in the spongy mesophyll.

The cells of the embryo contain aleurone grains and fixed oil.

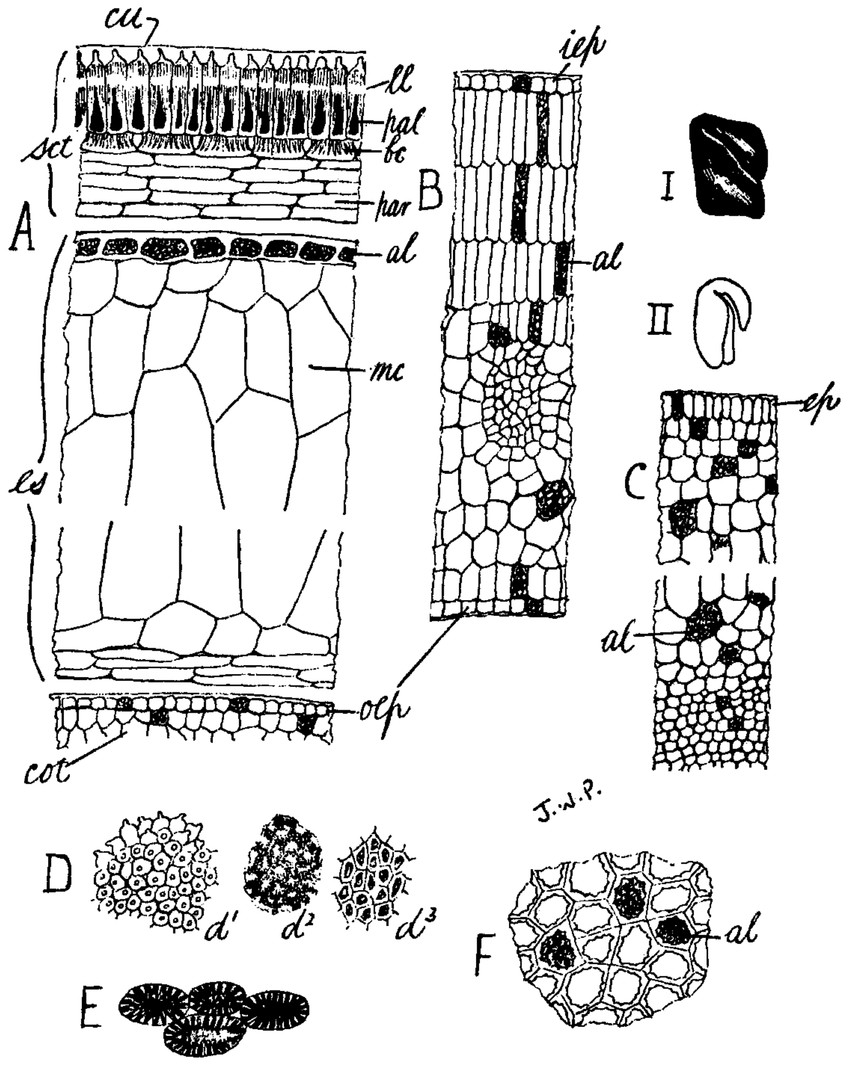

Fig. 15. FENUGREEK. I—Seed. II—Embryo. (A) Cross section through seed coat, endosperm, and part of cotyledon. (B) Cross section of cotyledon. (C) Cross section of radicle from epidermis to central zone. (D) Surface view of palisade cells of seed coat (d^1); as seen when microscope focused partly down (d^2); as seen when focused to base of cells (d^3). (E) Surface view of bearer cells. (F) Surface view of aleurone layer of endosperm.

al, aleurone; bc, bearer cells; cot, cotyledon; cu, cuticle; ep, epidermis; es, endosperm; iep, inner epidermis; ll, light line; mc, mucilage cells; oep, outer epidermis; pal, palisade cells; par, parenchyma; sct, seed coat.

XVII. MUSTARD, WHITE

Sinapis alba L.
Family: *Cruciferae*

[COMMONLY CALLED YELLOW MUSTARD]

GENERAL

An herbaceous, annual plant. Lower leaves pinnatifid, upper leaves sublyrate; leaves alternate along bristly branches, irregularly toothed, petiolate, hairy on both sides. Flowers in racemes, small, yellow; petals 4, cruciform; stamens tetradynamous; pistil bicarpellate. Fruit a bristly silique, roundish, ribbed, swollen at the seeds, and with a long ensiform beak; pods spreading in the raceme.

MORPHOLOGY

Seed yellowish, nearly globular, from about 1.5 to 3 mm (average of 25 seeds, 2.1 mm), minutely pitted, hilum scar, and with ridge and 2 parellel grooves or furrows externally indicating the position of the radicle in relation to the conduplicate cotyledons which form the bulk of the seed. Seed coat thin, endosperm meagre and imperceptible to the naked eye; large embryo, yellowish, with curved hypocotyl-radicle partially surrounded by 2 folded cotyledons. Seed becomes coated with mucilage when soaked in water.

Yellow mustard seeds are inodorous, and no odor results from crushing them in water (difference from black mustard seeds); taste, pungent.

HISTOLOGY

The tissues should be expanded with the aid of bleaching solution.

Seed

Cross section.

Seed Coat. This consists of: (a) thin cuticle; (b) epidermis consisting of large, mucilaginous cells nearly rectangular in shape, with convex outer walls; the mucilage is clearly stratified about a central column or axial cavity; (c) 2 layers of collenchyma cells; (d) a layer of palisade cells with pale straw-colored thickened walls in the lower part of the cells, and thin walls in the upper; and (e) 2 layers of collapsed parenchyma cells.

In the region of the hilum the palisade cells end. The parenchyma tissue underlying the palisade cells merges with that underlying the epidermis, and the whole tissue becomes several cells deep; in the outer part of the latter tissue small spiral vessels occur. (The structure is similar in black mustard seeds.) The collenchyma tissue increases from 2 layers to 3 or 4 layers toward the hilum region. There are no collenchyma cells in the immediate hilum region.

In surface view, the epidermal cells are polygonal in shape with thin, beaded walls; mucilage has central cavity. With polarized light each cell displays a striking, brilliant maltese cross effect. The thickening of the collenchyma cells is characteristic and noteworthy. The palisade cells are small, polygonal, and thick-walled; the thin-walled parts of the cells are not clearly distinguishable in surface view. The reticulations of the seed are only faintly discernible.

Endosperm. This consists of: (a) an outer layer of nearly quadrilateral to tangentially oblong, thick-walled cells containing aleurone grains; and (b) 6 or 7 layers of compressed cells.

In surface view, the aleurone cells are polygonal in shape and thick-walled.

Embryo. The embryo is large and consists of radicle and 2 folded cotyledons. The radicle consists of epidermis, several layers of isodiametric parenchyma cells, and a central core or zone of very small, thin-walled cells. The cotyledons consist of upper and lower epidermis, palisade cells, rudimentary spongy mesophyll, and rudimentary vascular tissue.

In surface view, daughter cells, usually in pairs, are a noteworthy feature of the epidermis of the cotyledons.

The cells of the embryo contain aleurone grains and fixed oil.

Ground White Mustard

Color light-yellow to pale brownish-yellow. The important identifying tissues are (a) fragments of the seed coat epidermis with mucilaginous cells; (b) collenchyma cells; (c) palisade cells with pale-colored thickening laid down on the inner and lower portions of their walls; (d) fragments of endosperm aleurone layer; and (e) fragments of the embryo with aleurone grains and fixed oil.

Ground Mustard

A blend of white and black mustard. See following chapter.

XVIII. MUSTARD, BLACK

Brassica nigra (L.) Koch
Family: *Cruciferae*

[COMMONLY CALLED BROWN MUSTARD]

GENERAL

An erect, herbaceous annual. Leaves alternate, petiolate, and variously shaped. Lower leaves large, rough, irregularly sinuate-dentate, lyrate-pinnate with the terminal lobe large and lower lobes small; rather hispid. Upper leaves smooth and moderately lobed. Uppermost leaves entire and narrow. Flowers in racemes, small, yellow; petals 4, cruciform; stamens tetradynamous; pistil bicarpellate. Fruit a silique, smooth, quadrangular, with a short, slender beak; pods nearly parallel to the axis of the raceme.

MORPHOLOGY

Seed dark reddish-brown, nearly globular, from about 1 to 1.6 mm (average of 25 seeds, 1.48 mm); finely but distinctly pitted, fine reticulations under microscope; hilum scar. Seed coat thin, endosperm imperceptible to the naked eye, embryo smaller but otherwise similar to that of white mustard. When soaked in water the seeds become coated with mucilage.

Black mustard seed is inodorous, but when crushed in water yields a sharp, piercing, irritating odor (presence of allyl isothiocyanate); taste, pungent.

HISTOLOGY

Seed

Cross section.

Seed Coat. This consists of: (a) thin cuticle; (b) an epidermal layer of mucilaginous cells tangentially oblong-rectangular in shape with convex outer walls; mucilage stratified, central column invisible or very faint; (c) a layer of large, thin-walled parenchyma cells; (d) a layer of palisade cells with dark-colored, thickened walls in the lower part, and thin walls in the upper; and (e) 1 or 2 layers of tangentially elongated pigment cells.

In surface view, the epidermal cells are polygonal in shape with thin, beaded walls; mucilage with central cavity. With polarized light each cell displays a bright maltese cross effect. The large parenchyma cells agree in size and and position with the reticulations of the seed coat. The reticulations of the seed coat are prominent and vary in size from about 88 to 133 microns, long axis. The palisade cells are small, polygonal, and thick-walled.

Endosperm. Consisting of (a) an outer layer of tangentially oblong, thick-walled cells containing aleurone grains; and (b) 3 or 4 layers of compressed cells.

In surface view, the aleurone cells are polygonal in shape and thick-walled.

Embryo. The embryo is similar to that described under white mustard.

Ground Black Mustard

Color, yellowish-brown. The important identifying tissues are (a) fragments of the seed coat epidermis with mucilaginous cells; (b) large parenchyma cells; (c) palisade cells with dark-colored thickening laid down on the inner and lower portions of their walls; (d) pigment cells; (e) fragments of endosperm aleurone layer; and (f) fragments of the embryo with aleurone grains and fixed oil.

Ground Mustard

To obtain the right taste and flavor it is the practice to blend white and black mustard, therefore, samples of pure mustard powder will contain the tissues of both white and black mustard seeds.

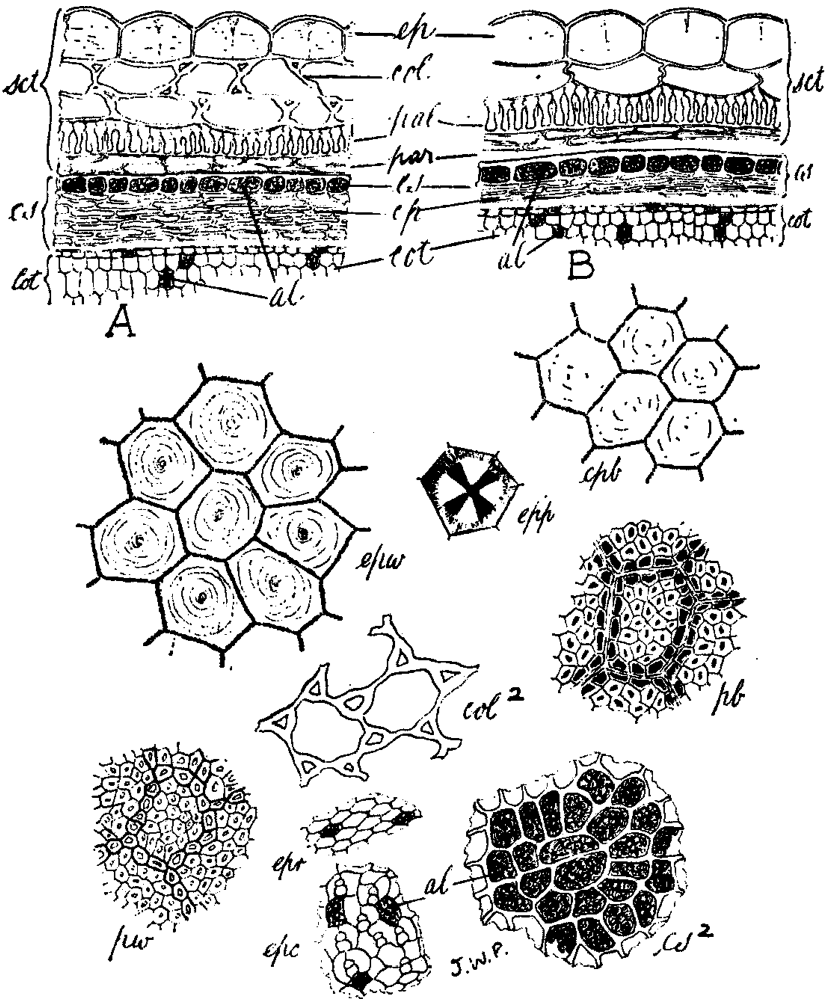

Fig. 16. MUSTARD SEED. (A) White. (B) Black Mustard; cross section through seed coat, endosperm, and part of cotyledon.

al, aleurone; col, collenchyma; cot, cotyledon; cp, compressed cells; ep, epidermis; es, endosperm; pal, palisade cells; par, parenchyma; sct, seed coat. Surface view: col², collenchyma; epb, epidermis of seed coat (black); epc, epidermis of cotyledon (white and black); epp, epidermis of seed coat with polarized light (white and black); epw, epidermis of seed coat (white); epr, epidermis of radicle (white and black); es², endosperm (white and black); pb, palisade cells, and prominent reticulation (black); pw, palisade cells, and faint reticulation (white).

XIX. POPPY

Papaver somniferum L.
Family: *Papaveraceae*

GENERAL

An annual herb reaching up to 4 feet in height, smooth, glaucous, with a branched stem. Leaves large, alternate, dull green, ovate, sinuate to dentate-serrate, clasping at the base. Flowers large, showy, varying in color from light pink to purple, and consisting of a receptacle borne on a long peduncle, erect, 2 green sepals, 4 colored petals, numerous stamens, syncarpous pistil, globose ovary bearing on its surface a radiate, sessile stigma. Fruit a capsule with numerous small seeds. Opium is obtained from this plant but the seeds are not narcotic.

The blue poppy seed of commerce may be the genuine blue poppy seed or it may be the white poppy seed artificially colored. The dye used for this purpose is water soluble and may be detected by shaking a few seeds in a little water contained in a test tube.

MORPHOLOGY

Seed grayish blue to dark blue, reniform, very small, about 1 to 1.25 mm in length, hilum distinct in a depression near one end; surface reticulated, the reticulations forming a raised-ridge network clearly visible with the aid of a hand lens. Seed coat thin; endosperm bulky; embryo consisting of radicle and 2 cotyledons embedded in the endosperm. Exudation of oil when pressure is applied to the seed with the finger nail.

Odor slight, pleasant, nutlike; taste agreeable and decidedly nutty.

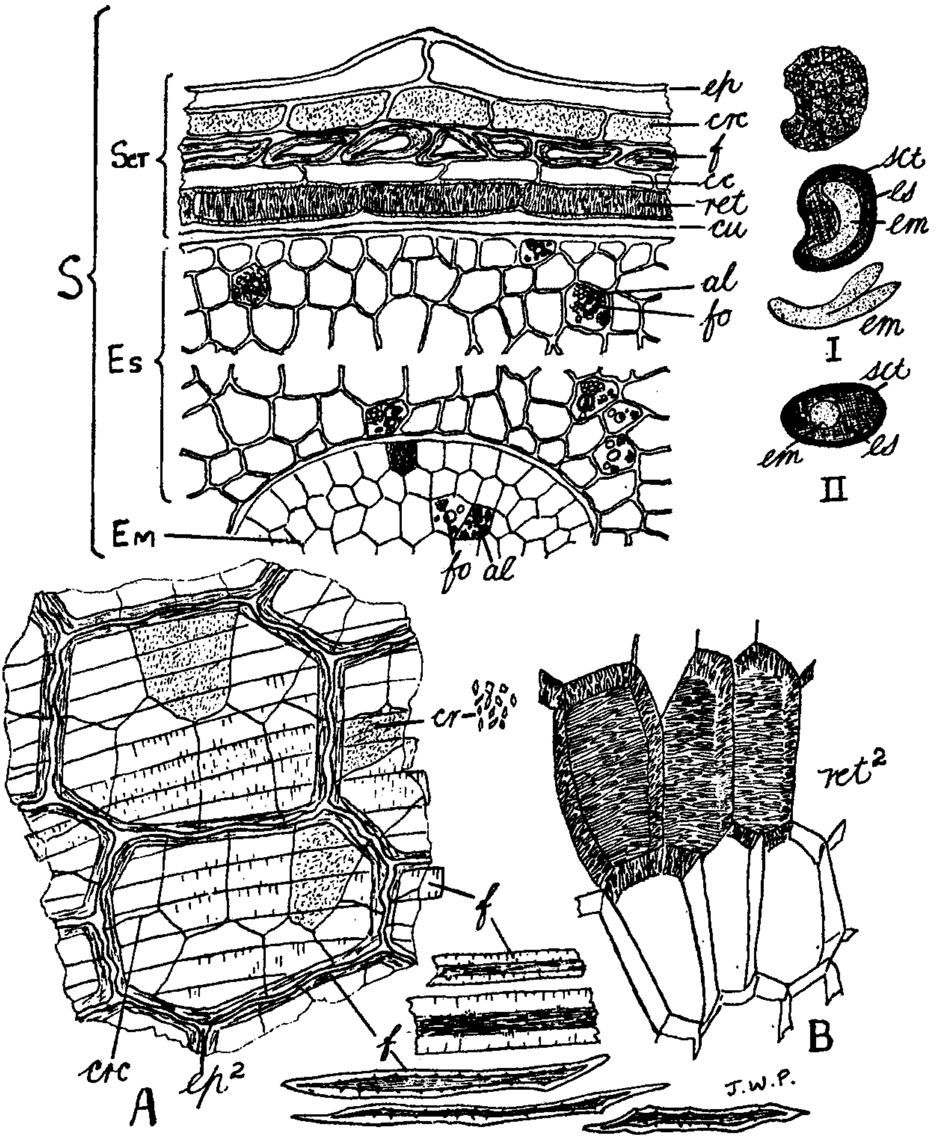

Fig. 17. POPPY SEED. I—Seed, whole; longitudinal section; and embryo. II—Cross section of seed. (S) Cross section of seed. (A) Surface view of seed coat. (B) Surface view of reticulated cells.

al, aleurone; cc, cross cells; cr, crystals; crc, crystal cells; cu, cuticle; em, embryo; ep, epidermis (ep², surface view); es, endosperm; f, fibers; fo, fixed oil; ret, reticulated cells (ret², surface view); sct, seed coat.

HISTOLOGY

Poppy seed is very small and sectioned with difficulty, but with care and patience sections which will permit a full study of the tissues can be obtained. Polarized light is very useful in an examination of the histological structure of this seed. The tissues can be expanded with the aid of bleaching solution.

Seed Coat

Cross section. Consisting of (a) an epidermis of tangentially-elongated, narrow, thin-walled cells; (b) a layer of parenchymatous cells containing numerous very small prismatic crystals of calcium oxalate; (c) a layer of thick-walled fibers, pronounced at the ridges of the seed coat. Fibers stain a weak blue with chlor-zinc-iodine following bleaching which would indicate that they are largely cellulose in composition; separation of the fibers is a difficult task; (d) a layer of parenchymatous cells; (e) a layer of reticulated cells. The reticulated cells are cellulose and stain blue with chlor-zinc-iodine; staining also permits a study of the detail of these cells; and (f) an inner cuticle. This cuticle is visible in an unstained section but its presence can be confirmed by staining a bleached section with chlor-zinc-iodine; the cuticle will be seen as a yellow membrane situated between the reticulated cells of the seed coat and the endosperm.

In surface view, the cells of the epidermis agree in size and shape with the deep surface reticulations of the seed. The ribs forming the reticulations consist of large, thick-walled fibers; the epidermal cells are shallow and thin-walled. The cells of the crystal layer are polygonal and contain numerous prismatic crystals of calcium oxalate; polarized light aids the study of these crystals. The fibers are broad, long, and lie at right angles to the underlying parenchyma and reticulated cells. The reticulated cells are polygonal in shape, and vary in size up to about 140 microns, long axis.

Endosperm and Embryo

The cells of the endosperm and embryo are polygonal and contain aleurone grains and globules of fixed oil. The embryo consists of radicle and 2 cotyledons.

XX. SESAME

Sesamum indicum L.
Family: *Pedaliaceae*

GENERAL

An annual, herbaceous plant with branched stem, 2 to 4½ feet or more in height, somewhat pubescent. Lower leaves opposite, often 3-lobed or parted; upper leaves alternate, oblong-lanceolate, serrate. Flowers about 1 inch long, pale rose or white, solitary, axillary, tubular-campanulate, 5-lobed. Fruit an oblong obtusely 4-sided, 2-loculed capsule (pod), containing small, flattish, pyriform seeds.

MORPHOLOGY

Unhulled Sesame Seed

Color varies with variety from yellowish-white to black through shades of gray and brown; flattened, pyriform; 2.5 to 3.5 mm in length, 1.5 to 2 mm in breadth, not more than 1 mm in thickness; raphe marked by a central longitudinal ridge on one side; a ridge around each side near the edge, distinct on some seed, indistinct on others; endosperm meagre; embryo large with radicle and 2 bulky cotyledons.

Hulled Sesame Seed

Divested of seed coat; creamy or pearly-white; flattened, pyriform; very slightly smaller than the unhulled seed; smooth, lustrous; and consisting of endosperm and embryo.

The product of the spice trade is usually the hulled seed.

Sesame seed has a very faint nutty odor, and an agreeable nutty taste.

HISTOLOGY

Seed Coat

Cross section. Tissues should be expanded with the aid of bleaching solution. The seed coat consists of (a) an epidermis of palisade or radially-elongated cells except at the ridges where the cells change in length and arrangement to form an outwardly-projecting pinnate group. The cells vary in size from about 30 to 60 microns on the sides of the seed, and from about 45 to 130 microns at the ridges; the cell walls are thin with the outer walls cutinized. Excepting at the ridges, each epidermal cell contains at its apex, within a very thin membranous tissue, a rosette-like group of calcium oxalate crystals. These crystal groups are brilliant with polarized light; (b) parenchymatous tissue with cells containing numerous prismatic crystals of calcium oxalate; at the ridges this tissue is fragmentary; and (c) an inner cuticle (stains yellow with chlor-zinc-iodine after bleaching).

Endosperm

Consisting of 3 to 4 layers of polygonal cells containing aleurone grains and globules of fixed oil.

Embryo

The embryo consists of radicle and 2 bulky cotyledons. The cotyledons are well developed and consist, in cross section, of an upper and lower epidermis of small rectangular cells, a palisade layer, polygonal parenchyma, and rudimentary vascular tissue. The cells contain aleurone grains and globules of fixed oil.

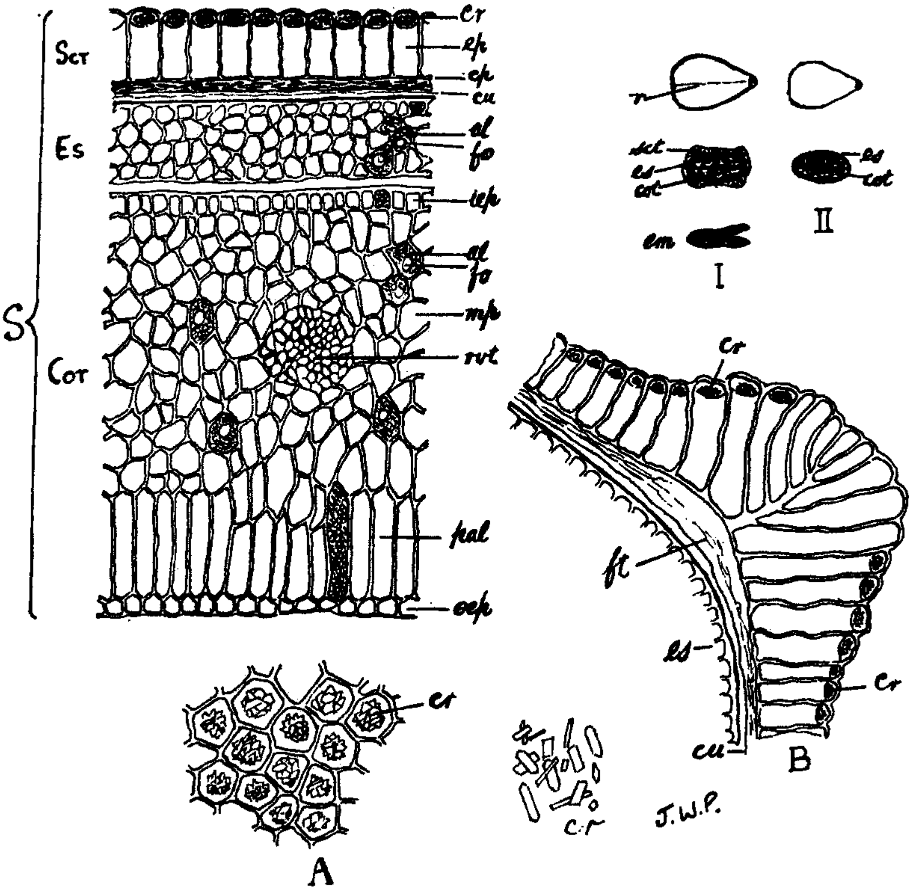

Fig. 18. SESAME. I—Unhulled seed. II—Hulled seed. (S) Cross section of seed. (A) Epidermis of seed coat with crystals. (B) Cross section of ridge of seed coat showing pinnate arrangement of epidermal cells.

al, aleurone; cot, cotyledon; cp, compressed cells; cr, crystals; cu, cuticle; em, embryo; ep, epidermis; es, endosperm; fo, fixed oil; ft, fragmentary tissue; iep, inner epidermal cells of cotyledon; mp, mesophyll of cotyledon; oep, outer epidermal cells; pal, palisade cells; r, raphe; rvt, rudimentary vascular tissue; sct, seed coat.

Umbelliferae

GENERAL

These are mostly perennial herbs. The name of this family is derived from the fact that the inflorescence of the plant is characteristically of the umbel type. The inflorescence is usually a compound umbel. Flowers small, regular, complete, and epigynous; calyx very small, inconspicuous, and seen only as 5 small teeth at the apex of the fruit. The ovary is inferior. Fruit a schizocarp, the ovary consisting of two fused carpels which separate at maturity into two 1-seeded mericarps which remain suspended for a time from a carpophore. The carpophore is divided in some species, partially divided in others, undivided in still others; it is a modified extension of the pedicel. Mericarps usually with prominent longitudinal ridges on the dorsal side, and tubes or vittae containing aromatic oil traversing the mesocarp.

Umbelliferae fruits employed as spices, and their main identifying characteristics, follow.

Anise: schizocarps ovoid; small; short hairs; numerous vittae; carpophore divided for a little more than half its length.

Caraway: dark colored; ridges prominent; 6 vittae; carpophore divides at the middle.

Celery: very small; smallest of the Umbelliferae spice fruits; schizocarps nearly circular; usually 6 vittae; carpophore divides near the top.

Coriander: schizocarps nearly globular with 10 straight and 10 wavy ridges; usually 2 vittae, commissural; carpophore undivided.

Cumin: hairy ridges, particularly the secondary ridges; 6 vittae; strong, heavy odor.

Dill: broadly oval or elliptical; conspicuous for wing-like lateral ridges; 6 vittae; carpophore divided.

Fennel: light-colored; largest of the Umbelliferae spice fruits; ridges very prominent; usually 6 vittae; carpophore divided.

Note: The number of vittae just given is the number to each mericarp. They are seen in a cross section of the larger fruits with the aid of a good hand lens, in the smaller fruits only with the aid of a microscope.

XXI. ANISE

Pimpinella anisum L.
Family: *Umbelliferae*

GENERAL

An annual herbaceous plant with an erect, smooth, branching stem rising to a height of 1 foot or more. Leaves petiolate, and varying from broadly triangular, cleft, and incised-serrate at the base of the plant to narrow segments, and trifid in the upper plant. Flowers small, white, and borne in large, compound umbels. Fruits are schizocarps with numerous vittae or oil tubes. Each mericarp contains a single seed.

MORPHOLOGY

Anise fruit, commonly called aniseed, is a schizocarp, ovoid, grayish-green to grayish-brown, 2 to 5 mm, short stylopodium, usually with pedicel, and consists of 2 mericarps attached to a carpophore divided a little over half its length.

The mericarp is broadly ovoid, flat or concave on the commissural side, convex on the dorsal side with 5 light-colored longitudinal ridges and numerous short hairs; the hairs are visible with the aid of a lens.

The pericarp contains many vittae or oil canals and encloses a single seed with a small embryo embedded in the endosperm toward the apex of the mericarp.

Anise has a characteristic, agreeable, aromatic odor, and a pleasant, aromatic taste.

HISTOLOGY

Pericarp

Cross section.

Exocarp. Consisting of a thin cuticle, a layer of epidermal cells oblong-rectangular in shape or nearly so, and numerous unicellular and some dicellular non-glandular, strongly papillose hairs varying in length to about 150 microns, blunt at the apex and broad at the base, mostly curved. Some of the dicellular hairs contain a brownish substance.

In surface view, the cuticle is striated; the epidermal cells are polygonal in shape, and vary in size to about 40 microns, long axis. Head on, the hairs appear as small circles ringed with dots. Stomata are present.

Mesocarp. Consisting of thin-walled, isodiametric or elliptical parenchyma cells in the outer mesocarp, and 3 layers of tangentially elongated cells in the inner mesocarp. Toward the apex of the mericarp the inner mesocarp cells adjoining the endocarp in the central commissural region are sclerenchymatous.

Endocarp. Consisting of a layer of tangentially-elongated, thin-walled cells. Toward the apex of the mericarp the endocarp cells in the central commissural region are nearly quadrilateral in shape and are sclerenchymatous.

In surface view, with the exceptions given below, the endocarp cells are transversely long, narrow, and thin-walled. On the commissural side of the mericarp, toward the base, the endocarp cells are longitudinally elongated and thin-walled; in the central commissural region they vary in shape from nearly quadrilateral to transversely long and narrow, are mostly thin-walled but some are weakly sclerenchymatous; toward the apex they vary in shape from nearly quadrilateral to longitudinally oblong-rectangular and are strongly sclerenchymatous.

Fibrovascular Bundles. Five fibrovascular bundles traverse the outer mesocarp and form the ridges of the mericarp. Both spiral and reticulate vessels occur; the xylem fibers are pitted and vary in length. The phloem fibers are long and narrow.

Vittae. There are many dorsal vittae, and 2 commissural vittae. The dorsal vittae are small, up to about 165 microns, tangential axis; the commissural vittae are large, up to about 495 microns, tangential axis. The vittae are yellowish-brown, elliptical, schizogenous, secretory cavities.

In surface view, the vittae are yellowish-brown, tubular tissues consisting of small, polygonal, cutinized cells; membranous cross walls occur at intervals.

Seed

Cross section.

Seed Coat. This consists of a single layer of epidermal cells on the dorsal side, an epidermal layer and several underlying layers of parenchyma cells on the commissural side; the raphe is centrally situated in the latter tissue. The epidermal cells are tangentially oblong-rectangular; the parenchyma cells are tangentially elliptical except around the raphe where they are small and isodiametric or irregular in shape. The outer walls of the epidermal cells are cutinized. In surface view, the epidermal cells are polygonal in shape. An inner, thin cuticle is present.

Endosperm. This consists of polygonal cells with moderately thick, colorless walls. The cell contents consist of aleurone grains and globules of fixed oil. There is a rosette crystal of calcium oxalate embedded in many of the larger aleurone grains.

Embryo. The embryo varies in length from about 1350 to 1800 microns, and consists of radicle and 2 cotyledons; the radicle lies toward the apex of the seed. The cells of the embryo contain aleurone grains and globules of fixed oil.

Pedicel

The pedicel consists of a smooth cuticle, an epidermis with occasional hairs, cortex, vittae, and a cylindrical core of fibrovascular tissue. In cross section, the epidermal cells are oblong-rectangular in shape, or nearly so, with thick outer walls. The cortex cells are small, isodiametric, and thin-walled. A few weakly developed collenchyma cells underlie the epidermis near the vittae. The vittae are 2 in number. In surface view, the epidermal cells are polygonal in shape excepting over collenchyma tissue where they are oblong-rectangular. Stomata are fairly numerous.

Carpophore

The carpophore is a modified extension of the pedicel and divides for just over half its length.

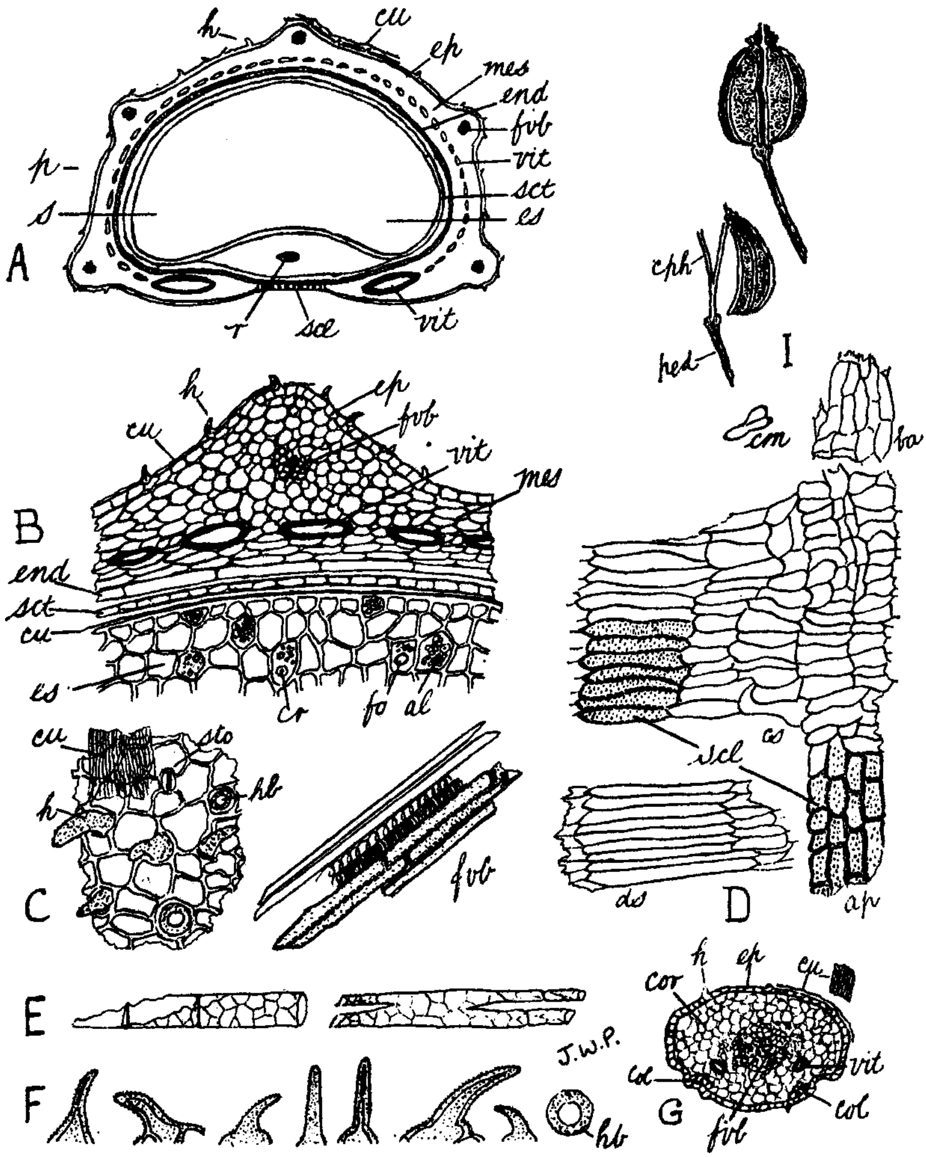

Fig. 19. ANISE. I—Schizocarp (above); mericarp (below). (A) Cross section of mericarp. (B) Cross section through ridge. (C) Epidermis of pericarp, surface view. (D) Endocarp, surface view. (E) Longitudinal view of vitta, simple and branched. (F) Hairs. (G) Cross section of pedicel.

al, aleurone; ap, apex; ba, base; col, collenchyma; cor, cortex; cph, carpophore; cr, crystal; cs, commmissural side; cu, cuticle; ds, dorsal side; em, embryo; end, endocarp; ep, epidermis; es, endosperm; fo, fixed oil; fvb, fibrovascular bundle; h, hair; hb, hair base; mes, mesocarp; p, pericarp; ped, pedicel; r, raphe; s, seed; scl, sclerenchyma; sct, seed coat; sto, stoma; vit, vitta.

XXII. CARAWAY

Carum carvi L.
Family: *Umbelliferae*

GENERAL

This is a biennial herbaceous plant reaching a height of about 2 feet. Leaves compound with linear segments. Flowers small, white, and produced in compound umbels. Fruits schizocarps; each mericarp contains a single seed.

MORPHOLOGY

The dried product of commerce consists almost entirely of separated mericarps. Mericarps hard, sharp, light to dark brown, 4 to 6 mm in length, some straight but mostly curved, short stylopodium, flat on the commissural side, convex on the dorsal side with 5 prominent, light-colored, longitudinal ridges or ribs; pedicel rarely present.

The pericarp contains 4 dorsal and 2 commissural vittae, and encloses a single seed with a small embryo embedded in the endosperm toward the apex.

The carpophore divides at the middle.

Caraway has a characteristic, agreeable odor, and an aromatic, warm, somewhat sharp taste.

HISTOLOGY

Pericarp.

Cross section.

Excarp. Consisting of cuticle, and a layer of epidermal cells tangentially oblong-rectangular in shape or nearly so; the epidermal cells over the ridges have thick outer walls.

In surface view, the epidermal cells are somewhat wavy-walled and polygonal in shape except over the ridges where they are straight-walled and longitudinally oblong or nearly so. The cell walls are beaded. Prismatic crystals of calcium oxalate occur in most of the cells. A few stomata are present.

Mesocarp. Consisting of tangentially elliptical cells in the outer mesocarp, and 3 or 4 layers of closely compressed, yellowish cells in the inner mesocarp.

Endocarp. Consisting of a layer of tangentially oblong, broad cells except in the central commissural region of the mericarp where they become radially oblong or quadrilateral in shape.

In surface view, the endocarp cells are transversely elongated except in the central commissural region of the mericarp where they are longitudinally oblong, and at the apex where they become quadrilateral or polygonal in shape. On the dorsal side of the mericarp the endocarp cells vary in size from about 45 to 135 microns, long axis, and from about 14 to 22 microns, short axis; on the commissural side they vary in size from about 45 to 180 microns, long axis, and from about 9 to 22 microns, short axis. The cell walls are thin except in the central and apex commissural regions where they become, for the most part, sclerenchymatous.

Fibrovascular Bundles. Five fibrovascular bundles traverse the mesocarp; 3 of these bundles form the dorsal ridges, and 2 the commissural or marginal ridges. In the basal and apex regions of the mericarp a number of pitted sclerenchyma cells of various shapes and sizes accompany the fibrovascular bundles of the commissural ridges.

Vittae. There are 4 dorsal, and 2 commissural, vittae. The dorsal vittae vary from about 220 to 420 microns, long axis; the commissural vittae from about 198 to 288 microns, long axis. The vittae are yellowish-brown, elliptical, schizogenous, secretory cavities; in surface view, they are yellowish-brown, tubular tissues consisting of cutinized, polygonal cells; membranous cross walls occur at intervals.

Unlike other fruits of the Umbelliferae considered in this work, there are, in addition to the vittae discussed above, 5 small, schizogenous, secretory cavities in the outer mesocarp, 1 at each ridge above and adjoining the fibro vascular bundle. These vittae are isodiametric or elliptical in shape, and vary in size from about 20 to 45 microns diameter or long axis. In surface view, they are yellowish-brown, narrow, tubular tissues traversing the length of the mericarp.

Seed

Cross section.

Seed Coat. Consisting of a layer of epidermal cells on the dorsal side of the seed, and a layer of epidermal cells with underlying parenchyma on the commissural side; the raphe is centrally situated in the latter tissue. The epidermal cells are tangentially oblong-rectangular in shape, and have cutinized outer walls; the parenchyma cells are thin-walled, small, and compressed. In surface view, the epidermal cells are polygonal in shape. An inner, thin cuticle is present.

Endosperm. Consisting of polygonal cells with moderately thick, colorless walls. The cell contents consist of aleurone grains and globules of fixed oil. There is a rosette crystal of calcium oxalate embedded in many of the larger aleurone grains.

Embryo. The embryo varies in length from about 1800 to 2000 microns and consists of radicle and 2 cotyledons. It is embedded in the endosperm with the radicle toward the apex of the seed. The cells contain aleurone grains and globules of fixed oil.

Pedicel

A pedicel is present on very few caraway fruits. It is similar to that described under fennel.

Carpophore

The carpophore is a modified extension of the pedicel and is divided for about half its length.

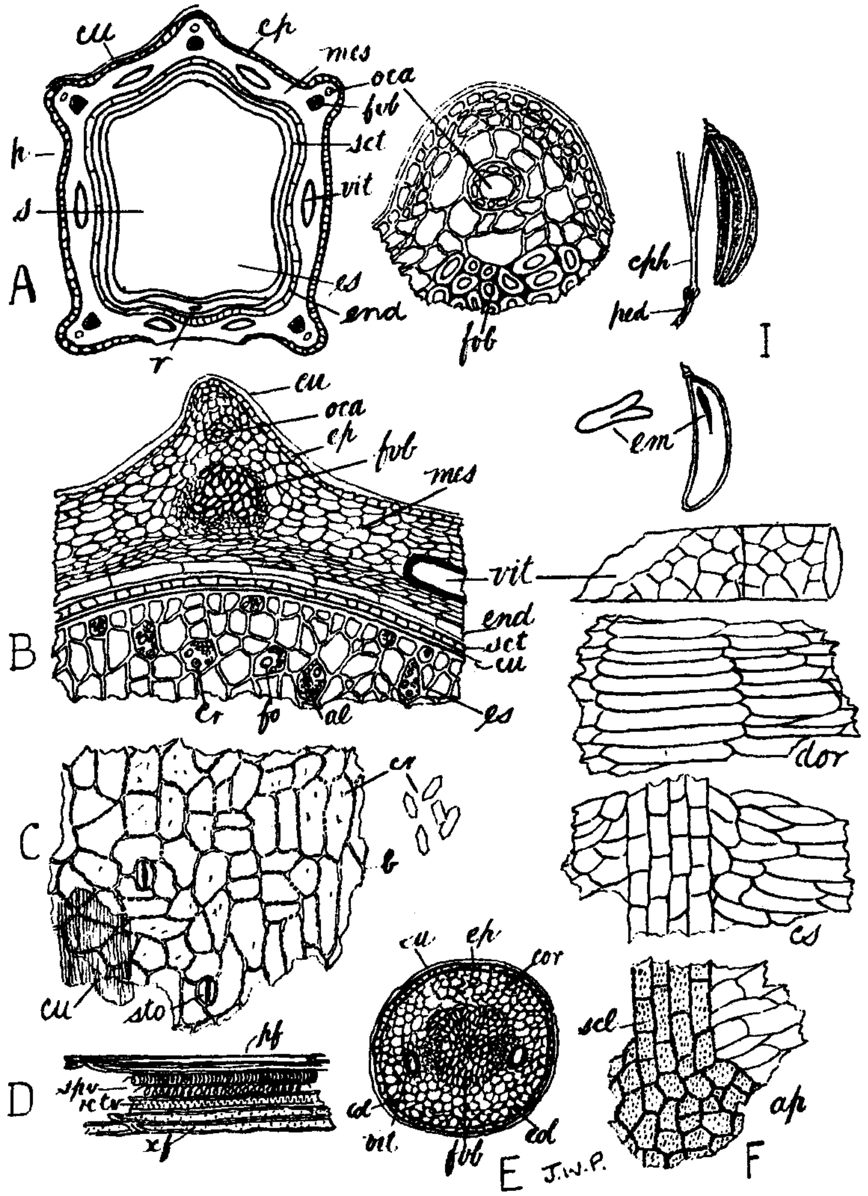

Fig. 20. CARAWAY. I—Mericarp. (A) Cross section of mericarp. (B) Cross section through ridge. (C) Epidermis of pericarp, surface view. (D) Fibro vascular tissue. (E) Cross section of pedicel. (F) Endocarp, surface view.

al, aleurone; ap, apex; b, beaded walls; col, collenchyma; cor, cortex; cph, carpophore; cr, crystals; cs, commissural side; cu, cuticle; dor, dorsal; em, embryo; end, endocarp; ep, epidermis; es, endosperm; fo, fixed oil; fvb, fibrovascular bundle; mes, mesocarp; oca, oil canal; p, pericarp; ped, pedicel; pf, phloem fibers; r, raphe; retv, recticulated vessel; s, seed; scl, sclerenchyma; sct, seed coat; spv, spiral vessel; sto, stoma; vit, vitta; xf, xylem fibers.

XXIII. CELERY

Apium graveolens L.
Family: *Umbelliferae*

GENERAL

Cultivated celery is a biennial herb reaching a height of about 18 inches. Root leaves well developed, succulent, numerous; leaflets usually 3 pair and a terminal one, ternately compound, coarsely toothed or cleft. Flowers white, very small, and produced in compound umbels. Fruits schizocarps; each mericarp contains a single seed.

MORPHOLOGY

The dried celery fruits of the spice trade, commonly but erroneously called celery seeds, consist of schizocarps and separated mericarps, many with pedicel attached.

The schizocarp is very small, only a very occasional fruit exceeding 1.6 mm, nearly circular, grayish-brown, and consists of 2 mericarps attached to a carpophore divided near the top.

The mericarp is flat to slightly concave on the commissural side, and convex on the dorsal side with 5 light-colored longitudinal ridges.

The pericarp usually contains 4 dorsal and 2 commissural vittae but occasionally more, and encloses a single seed with a small embryo embedded in the endosperm toward the apex of the mericarp.

The fruit has the well-known celery aroma and taste, the latter warm and slightly bitter.

HISTOLOGY

Pericarp

Cross section.

Exocarp. This consists of a cuticle and a layer of epidermal cells, many of which are papillose.

In surface view, the cuticle is strongly striated; the epidermal cells are irregular in shape with thin, wavy walls except over the ridges of the mericarp where they become longitudinally elongated with straighter, thicker walls. Head on, the papillae appear as small circles with wrinkled rims. Stomata are present but not abundant.

Mesocarp. This consists of tangentially elliptical parenchyma cells in the outer mesocarp, and a layer of tangentially elongated cells with pale-yellowish walls in the inner mesocarp; some of the latter cells become sclerenchymatous in the central and apex commissural regions of the mericarp.

Endocarp. This consists of a layer of tangentially elongated, narrow, pale-yellowish cells.

In surface view, the endocarp cells are elongated, narrow, and thin-walled; mostly transverse, occasionally parqueted in the basal and apex regions of the mericarp, longitudinally oblong in the central commissural region.

Fibrovascular Bundles. Five fibrovascular bundles traverse the outer mesocarp; 3 of these form the dorsal ridges, and 2 the commissural ridges of the mericarp. Lignified, reticulated cells accompany the bundles; they are particularly numerous in the apex region. The xylem vessels are spiral.

Vittae. Usually there are 4 dorsal, and 2 commissural, vittae, but additional vittae are occasionally present. The vittae are yellowish-brown, elliptical, schizogenous, secretory cavities varying from about 117 to 166 microns, long axis.

In surface view, the vittae are yellowish-brown, tubular tissues consisting of cutinized, polygonal cells; membranous cross walls occur at intervals.

Seed

Cross section.

Seed Coat. This consists of a layer of epidermal cells on the dorsal side of the seed, and a layer of epidermal cells with underlying parenchyma on the commissural side; the raphe is centrally situated in the latter tissue. The epidermal cells are tangentially oblong-rectangular in shape and have cutinized outer walls; the parenchyma cells are thin-walled and elliptical in shape except around the raphe where they are isodiametric or irregular.

In surface view, the epidermal cells are polygonal in shape. An inner, thin, smooth cuticle is present.

Endosperm. This consists of polygonal cells with moderately thick, colorless walls. The cell contents consist of aleurone grains and globules of fixed oil. There is a rosette crystal of calcium oxalate embedded in many of the larger aleurone grains.

Embryo. The embryo varies in length from about 400 to 500 microns, and consists of radicle and 2 cotyledons. It is embedded in the endosperm with the radicle toward the apex of the seed. The cells contain aleurone grains and fixed oil.

Pedicel

Except for the absence of palisade-like cells in the cortex, the presence of only a small amount of collenchyma tissue, and a striated cuticle, the pedicel is similar to that described under fennel.

Carpophore

The carpophore is a modified extension of the pedicel and is divided from a point very close to the apex of the mericarp.

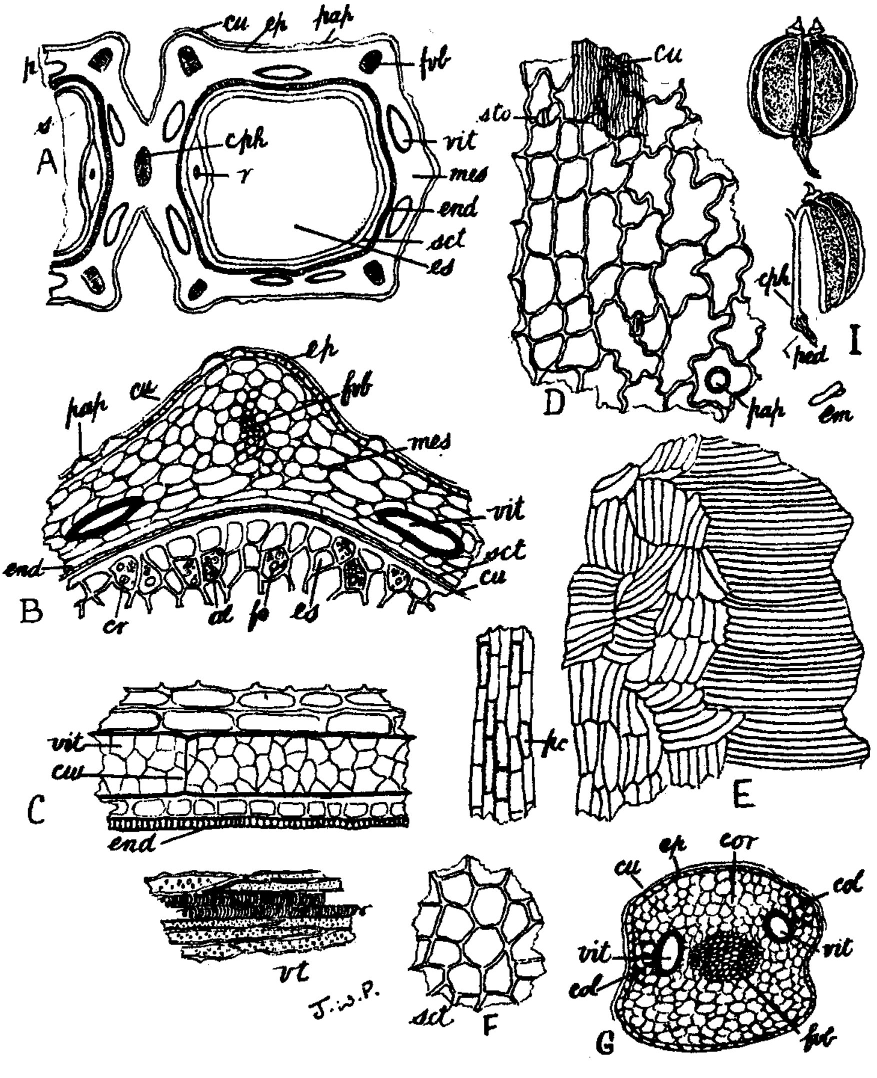

Fig. 21. CELERY. I—Schizocarp (above); mericarp (below). (A) Cross section of mericarp. (B) Cross section through ridge. (C) Longitudinal view of vitta. (D) Epidermis of pericarp. (E) Endocarp. (F) Seed coat. [D, E, and F, in surface view.] (G) Cross section of pedicel.

al, aleurone; col, collenchyma; cor, cortex; cph, carpophore; cr, crystal; cu, cuticle; cw, cross wall; em, embryo; end, endocarp; ep, epidermis; es, endosperm; fo, fixed oil; fvb, fibrovascular bundle; mes, mesocarp; p, pericarp; pap, papilla; ped, pedicel; pc, pitted cell; r, raphe; s, seed; sct, seed coat; sto, stoma; vit, vitta; vt, fibrovascular tissue.

XXIV. CORIANDER

Coriandrum sativum L.
Family: *Umbelliferae*

GENERAL

This is an annual herb growing to a height of about 2 feet. Lower leaves broad and deeply segmented or lobed; upper leaves composed of very narrow, linear segments. Flowers small, pinkish, and produced in compound umbels. Fruits schizocarps, spherical and ridged.

MORPHOLOGY

Dried coriander fruit is a nearly globular schizocarp, yellowish-brown, 3 to 5 mm in diameter, with 10 straight and 10 wavy longitudinal ridges, a depression at the base, 5 small calyx teeth and a conical stylopodium at the apex. The schizocarp of coriander consists of 2 mericarps attached to an undivided carpophore.

The mericarp is concave on the commissural side, and convex on the dorsal side.

The pericarp is without vittae on the dorsal side, and usually with 2 vittae on the commissural side but occasionally more. The pericarp encloses a single seed with a small embryo embedded in the endosperm toward the apex of the seed.

Coriander has a slight, fragrant odor, and a pleasantly aromatic taste.

HISTOLOGY

Pericarp

Cross section.

Exocarp. This consists of cuticle, an epidermis of thick-walled cells tangentially oblong-rectangular in shape or nearly so, and 2 supporting layers of thick-walled, compressed cells.

In surface view, the cuticle is striated; the epidermal cells are polygonal in shape, and vary in size up to about 45 microns, long axis, and have thick, pitted walls. Each cell contains 1 or more prismatic crystals, or a rosette-like group of microcrystals of calcium oxalate. Stomata are present.

Mesocarp. This includes an outer mesocarp consisting of (a) about 4 layers of tangentially oblong, thin-walled, parenchyma cells up to about 45 microns, long axis; (b) a layer of large, thin-walled, parenchyma cells which become palisade-like in the ridge regions; and (c) small, irregular or polygonal parenchyma cells adjoining a fiber layer.

There is also a fiber layer consisting of densely packed sclerenchyma fibers. Groups of fibers cross one another at various angles, frequently right angles. In surface view, the fibers follow a sinuous path.

Finally, there is an inner mesocarp consisting of (a) about 3 layers of thin-walled, tangentially elongated cells up to about 90 microns, long axis; and (b) 2 layers of thick-walled, pitted, tangentially elliptical cells up to about 90 microns, long axis; the walls of the cells adjoining the endocarp are the thickest of this tissue.

Endocarp. This consists of a layer of tangentially long, narrow cells, excepting where parqueting occurs.

In surface view, consisting of elongated, narrow cells up to about 300 microns, long axis, and 6 microns, short axis; transverse, occasionally parqueted.

Fibrovascular Bundles. Unlike the other Umbelliferae fruits considered in this work, the fibrovascular tissue is not conspicuous in cross section. It adjoins the fiber layer and is best studied in longitudinal section. Pitted, reticulated, and spiral vessels occur in the xylem.

Vittae. There are no dorsal vittae. Two commissural vittae are usually present, but, occasionally, additional commissural vittae occur. The vittae are elliptical, schizogenous, secretory cavities varying in size from about 150 to 300 microns, long axis, and from about 60 to 75 microns, short axis. They are flanked by thick-walled cells.

In surface view, the vittae are yellowish-brown, broad, tubular tissues consisting of small, polygonal cells with beaded walls; there are no cross walls.

Seed

Cross section.

Seed Coat. This consists of a layer of epidermal cells on the dorsal side, and a layer of epidermal cells with underlying parenchyma on the commissural side; the raphe is centrally situated in the latter tissue. The epidermal cells are thick-walled, and tangentially oblong-rectangular in shape excepting around the raphe where they are isodiametric or irregular. The outer walls of the epidermal cells are cutinized.

In surface view, the epidermal cells are polygonal in shape and thick-walled. An inner, thin, cuticle is present.

Endosperm. This consists of polygonal cells with moderately thick, colorless walls. The cell contents consist of aleurone grains and globules of fixed oil. A rosette crystal of calcium oxalate is embedded in many of the larger aleurone grains.

Embryo. The embryo varies in length from about 1000 to 1150 microns, and consists of radicle and 2 cotyledons. It is embedded in the endosperm with the radicle toward the apex of the seed. The cell contents are aleurone grains and globules of fixed oil.

Pedicel

The pedicel is similar to that described under fennel excepting that few, if any, palisade-like cells occur in the cortex parenchyma; the outer walls of the epidermal cells are thick, and the cuticle is faintly striated.

Carpophore

The carpophore is a modified extension of the pedicel and is not divided.

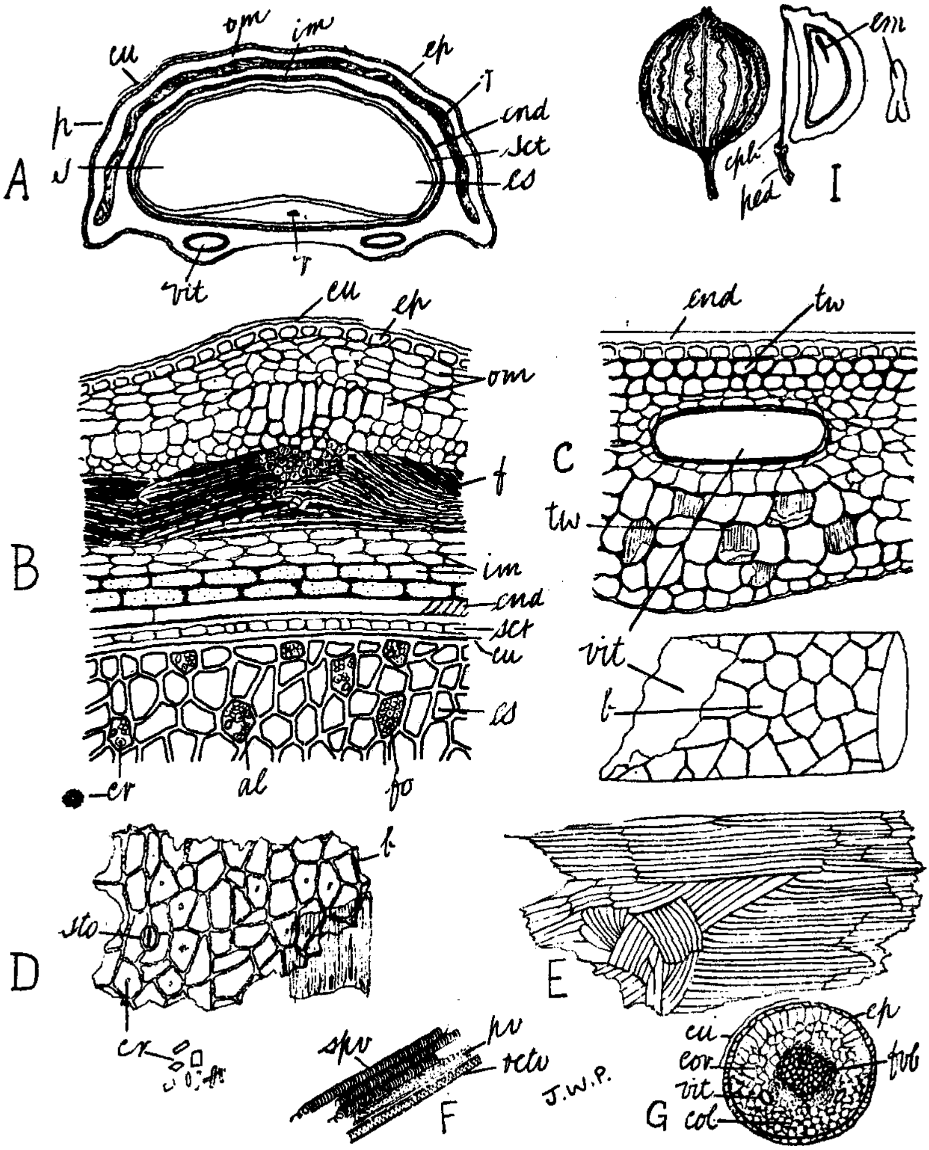

Fig. 22. CORIANDER. I—Schizocarp (left); mericarp (right). (A) Cross section of mericarp. (B) Cross section through primary ridge. (C) Cross section through commissural vitta. (D) Epidermis of pericarp, surface view. (E) Endocarp, surface view. (F) Vascular tissue. (G) Cross section of pedicel.

al, aleurone; b, beaded walls; col, collenchyma; cor, cortex; cph, carpophore; cr, crystals; cu, cuticle; em, embryo; end, endocarp; ep, epidermis; es, endosperm; f, fiber layer; fo, fixed oil; fvb, fibrovascular bundle; im, inner mesocarp; om, outer mesocarp; p, pericarp; ped, pedicel; pv, pitted vessel; r, raphe; retv, reticulated vessel; s, seed; sct, seed coat; spv, spiral vessel; sto, stoma; tw, thickened walls; vit, vitta.

XXV. CUMIN

Cuminum cyminum L.
Family: *Umbelliferae*

GENERAL

This is an annual, low-growing herb with finely divided leaves and small, white or rose-colored flowers produced in compound umbels. Fruits schizocarps; each mericarp contains a single seed.

MORPHOLOGY

Schizocarp ovoid-elongated, frequently with pedicel, stylopodium divided, yellowish-brown, 3 to 6.5 mm in length, and consisting of 2 mericarps attached to a carpophore divided from a point near the base.

Mericarp concave on the commissural side, convex on the dorsal side; 5 prominent, primary longitudinal ridges with a number of short hairs; 4 less distinct, secondary longitudinal ridges with numerous long hairs.

The pericarp contains 4 dorsal and 2 commissural vittae, and encloses a single seed with embryo embedded in the endosperm.

Cumin has a strong, heavy, distinctive odor, and a warm, aromatic taste.

HISTOLOGY

Pericarp

Cross section.

Exocarp. This consists of a thin cuticle and a layer of epidermal cells oblong-rectangular in shape or nearly so, with hairs occurring over the ridges. The hairs of the secondary ridges are much longer than those of the primary ridges, occasionally reaching 2 mm. The hairs are multicellular, multiseriate, broad at the base and rounded at the apex.

In surface view, the cuticle is striated. The epidermis of the primary ridges and the channels consists of irregular-shaped cells with thin, wavy or sinuous walls; stomata are present. The epidermis of the secondary ridges consists of cells longitudinally elongate-irregular in shape with moderately thick walls; there are no stomata.

Mesocarp. This consists of tangentially elliptical parenchyma cells with thin, colorless walls in the outer mesocarp, and tangentially elliptical cells with somewhat thicker, pale-yellowish walls in the inner mesocarp.

Endocarp. This consists of a layer of tangentially elongated, narrow cells with pale-yellowish walls. The cell walls are thin except in the apex region of the commissural side of the mericarp where they are thick and scerenchymatous.

In surface view, the thin-walled cells are transversely elongated and vary in size up to about 250 microns, long axis, and up to 14 microns, short axis. The sclerenchymatous cells vary in shape, size and arrangement; some are transversely elongated and narrow, others from transversely oblong to irregular and varying in width; those of the commissural apex region are longitudinally oblong.

Fibrovascular Bundles. Five fibrovascular bundles traverse the outer mesocarp and form the 5 primary ridges of the mericarp. Both spiral and reticulate vessels occur; the fibers are pitted.

Vittae. There are 6 vittae. Four of these give rise to the secondary ridges of the mericarp, 2 are commissural vittae. The vittae are yellowish-brown, schizogenous, secretory cavities. The dorsal vittae are up to about 250 microns, tangential axis, the commissural vittae to about 300 microns. Occasionally an additional vitta is present. When this occurs, the extra vitta usually adjoins one of the dorsal vittae, each being smaller than the customary dorsal vittae.

In surface view, the vittae are yellowish-brown, tubular tissues consisting of small, polygonal, cutinized cells; membranous cross walls occur at intervals.

Seed

Cross section.

Seed Coat. This consists of a layer of epidermal cells on the dorsal side, a layer of epidermal cells and underlying parenchyma on the commissural side; the raphe is centrally situated in the latter tissue. The epidermal cells are tangentially oblong-rectangular in shape with cutinized outer walls. The parenchyma cells are thin-walled and elliptical except around the raphe where they are isodiametric or irregular in shape.

In surface view, the epidermal cells of the seed coat are polygonal in shape; the outer cells walls are thicker than the inner, particularly so on the commissural side. Each cell contains a prismatic crystal of calcium oxalate. An inner, thin cuticle is present.

Endosperm. This consists of polygonal cells with moderately thick, colorless walls. The cells contain aleurone grains and globules of fixed oil. A small, rosette crystal of calcium oxalate is embedded in many of the larger aleurone grains.

Embryo. The embryo is about 1400 microns in length, and consists of radicle and 2 cotyledons. It is embedded in the endosperm with the radicle toward the apex of the seed. The cell contents are aleurone grains and globules of fixed oil.

Pedicel

The pedicel consists of cuticle, epidermis with stomata, cortex, 2 vittae, and fibrovascular tissue. There is no collenchyma tissue, but parenchyma cells with somewhat thickened walls fan out from the vittae to the epidermis. The remaining cortex tissue consists of 2 layers of thin palisade-like cells, and thinwalled, isodiametric or irregular cells. A large, cylindrical mass of fibrovascular tissue forms the bulk and core of the pedicel.

Carpophore

The carpophore is a modified extension of the pedicel and is divided from a point near the base of the mericarp.

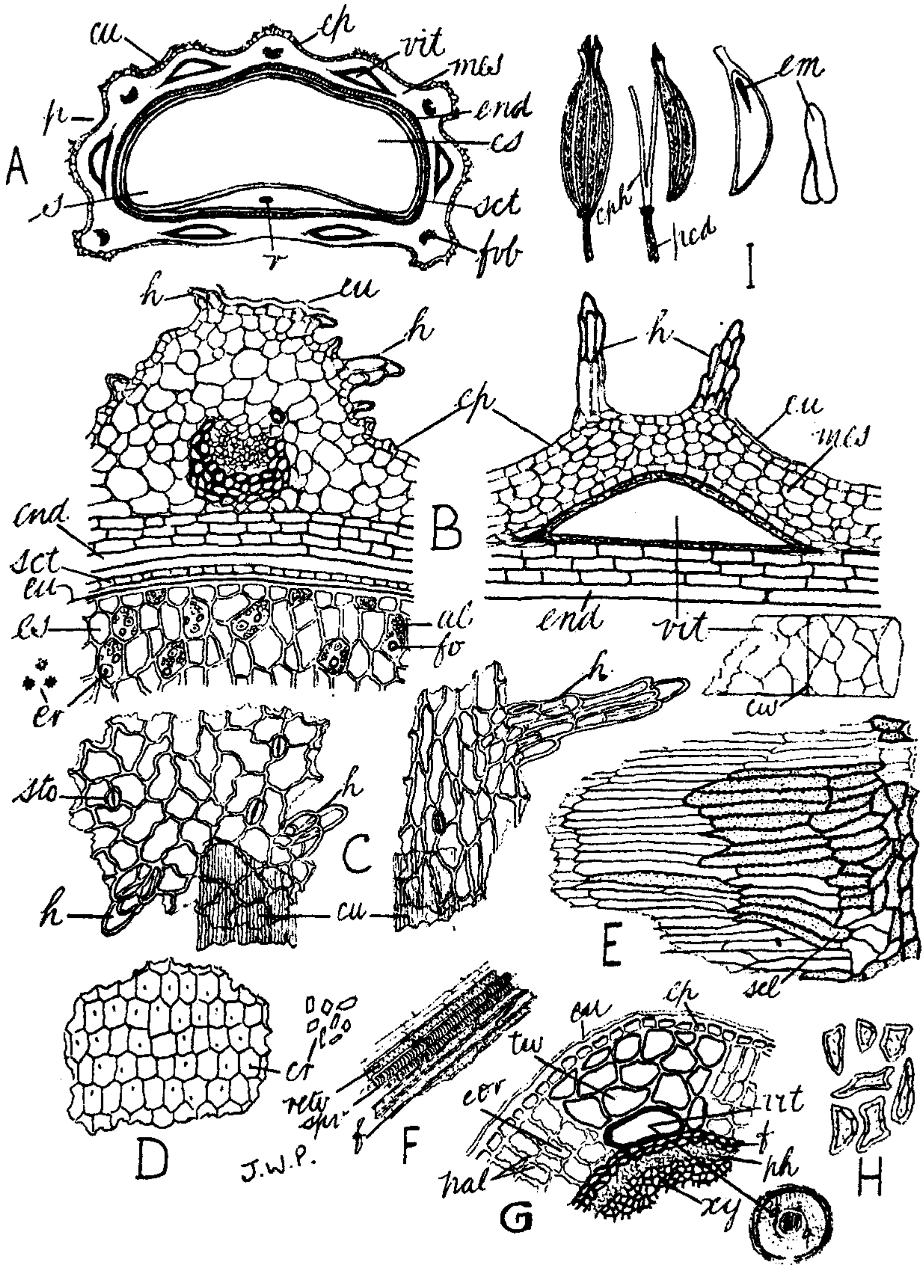

Fig. 23. CUMIN. I—Schizocarp (left); mericarp (right). (A) Cross section of mericarp. (B) Cross section through ridge (left); through dorsal vitta (right). (C) Surface view of epidermis of pericarp over primary ribs and channels (left); over secondary ribs (right). (D) Seed coat, surface view. (E) Endocarp, commissural side, apex region, surface view. (F) Fibrovascular tissue. (G) Cross section of pedicel. (H) Sclerenchyma cells occurring in dorsal mesocarp of apex region of pericarp.

al, aleurone; cor, cortex; cph, carpophore; cr, crystal (s); cu, cuticle; cw, cross wall; em, embryo; end, endocarp, ep, epidermis; es, endosperm; f, fibers; fo, fixed oil; fvb, fibrovascular bundle; h, hair; mes, mesocarp; p, pericarp; pal, palisade cells; ped, pedicel; ph, phloem; r, raphe; retv, reticulated vessel; s, seed; scl, sclerenchyma; sct, seed coat; spv, spiral vessel; sto, stoma; tw, thick-walled cells; vit, vitta; xy, xylem.

XXVI. DILL

Anethum graveolens L.
Family: *Umbelliferae*

GENERAL

This is an annual herb reaching a height of 3 or 4 feet, erect stem, finely divided light green leaves, and compound umbels of small yellow flowers. Fruits schizocarps; each mericarp contains a single seed. All parts of the plant are aromatic.

MORPHOLOGY

Schizocarp broadly oval or elliptical, light brown, short stylopodium, 3 to 5 mm long, 2 to 2.5 mm wide, and consisting of 2 mericarps attached to a divided carpophore. The commercial product consists mostly of mericarps with few pedicels present.

Mericarp concave on the commissural side, convex on the dorsal side, with 3 prominent, sharp, longitudinal dorsal ribs and 2 pale yellowish-brown, longitudinal, winglike lateral ribs.

The pericarp contains 4 dorsal vittae and 2 commissural vittae, and encloses a single seed with embryo embedded in the endosperm.

Dill has an aromatic odor faintly resembling that of caraway, and a warm, slightly sharp taste akin to caraway.

HISTOLOGY

Pericarp

Cross section.

Exocarp. This consists of cuticle and a layer of epidermal cells tangentially oblong-rectangular in shape or nearly so, with stomata.

In surface view, the cuticle is striated; the epidermal cells are polygonal.

Mesocarp. This consists of a layer of tangentially oblong-rectangular cells except some isodiametric and irregular parenchyma cells near the fibrovascular bundles, and several tangentially elliptical, reticulated sclerenchymatous cells flanking the fibrovascular bundles on the inner side toward the endocarp.

Endocarp. This consists of a layer of tangentially oblong-rectangular cells except (a) where parqueting occurs, and (b) in the central commissural region where the cells are nearly quadrilateral in shape. The cell walls are thin.

In surface view, the endocarp cells are elongated and narrow, mostly transverse, parqueted in the basal and apex regions of the mericarp, and longitudinally oblong in the central commissural region toward the apex.

Fibrovascular Bundles. Five fibrovascular bundles are present; 3 of these traverse the outer mesocarp and form the dorsal ridges or ribs, 2 are situated in the lateral ridges.

The lateral ridges are wide, often referred to as wings, and are characteristic of dill. The fibrovascular bundles occurring in the lateral ridges are large; they are flanked on the inner or endocarp side by reticulated, sclerenchymatous cells, and on the outer or edge side of the ridge by sclerenchyma cells with thick, pitted walls.

Both spiral and reticulate vessels occur in the xylem of dill.

Vittae. There are 4 dorsal and 2 commissural vittae. The dorsal vittae vary to about 203 microns, tangential axis, the commissural vittae to about 250 microns. The vittae are yellowish-brown, schizogenous secretory cavities.

In surface view, the vittae are yellowish-brown, tubular tissues consisting of large, polygonal, cutinized cells; membranous cross walls occur at intervals.

Seed

Cross section.

Seed Coat. This consists of a layer of epidermal cells on the dorsal side, an epidermal layer and underlying parenchyma on the commissural side; the raphe is centrally situated in the latter tissue. The epidermal cells are tangentially elliptical except around the raphe where they are small and isodiametric or irregular. The outer walls of the epidermal cells are cutinized.

In surface view, the epidermal cells are polygonal in shape. An inner, thin cuticle is present.

Endosperm. This consists of polygonal cells with somewhat thick, colorless walls. The cell contents consist of aleurone grains and globules of fixed oil. There is a rosette crystal of calcium oxalate embedded in many of the larger aleurone grains.

Embryo. The embryo is about 1000 microns in length. It consists of radicle and 2 cotyledons, with the radicle lying toward the apex of the seed. The cells contain aleurone grains and globules of fixed oil.

Pedicel

The pedicel is similar to that described under fennel.

Carpophore

The carpophore is a modified extension of the pedicel and is divided.

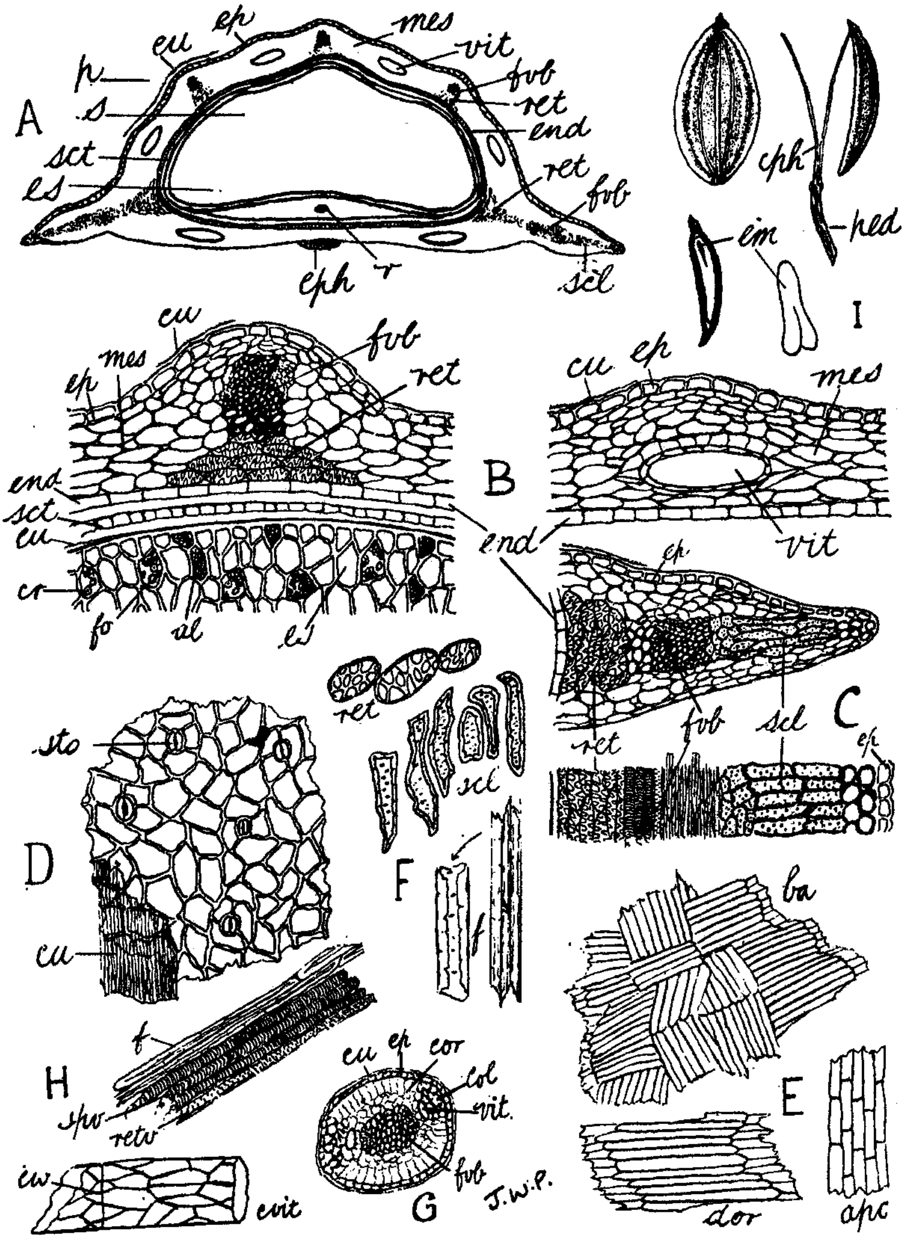

Fig. 24. DILL. I—Mericarp. (A) Cross section of mericarp. (B) Cross section through ridge (left); through vitta (right). (C) Lateral rib, cross section (above), longitudinal section (below). (D) Epidermis of pericarp, surface view. (E) Endocarp, surface view. (F) Reticulated cells, fibers and sclerenchyma occurring in lateral rib. (G) Cross section of pedicel. (H) Fibrovascular tissue; and commissural vitta (below).

al, aleurone; apc, apex, commissural side; ba, base; col, collenchyma; cor, cortex; cph, carpophore; cr, crystal; cu, cuticle; cw, cross wall; cvit, commissural vitta; dor, dorsal; em, embryo; end, endocarp; ep, epidermis; es, endosperm; f, fibers; fo, fixed oil; fvb, fibrovascular bundle; mes, mesocarp; p, pericarp; ped, pedicel; r, raphe; ret, reticulated cells; retv, reticulated vessel; s, seed; scl, sclerenchyma; sct, seed coat; spv, spiral vessel; sto, stoma; vit, vitta.

XXVII. FENNEL

Foeniculum vulgare Miller
Family: *Umbelliferae*

GENERAL

This is a biennial or perennial herb with finely divided green leaves. Flowers small, yellow, and produced in compound umbels. Fruits schizocarps; each mericarp contains a single seed. All parts of the plant are aromatic.

MORPHOLOGY

Schizocarp oblong-oval or elliptical, pale yellowish-brown with a tinge of green, usually with long pedicel, short stylopodium, 4 to 8 mm in length, and consisting of 2 mericarps attached to a divided carpophore.

Mericarp straight or curved, concave on the commissural side, convex on the dorsal side with 5 prominent longitudinal ridges or ribs.

The pericarp usually contains 4 dorsal and 2 commissural vittae but additional vittae are seen in some cross sections. The pericarp encloses a single seed with embryo embedded in the endosperm.

Fennel has a pleasant, aromatic odor and taste strongly resembling that of anise.

HISTOLOGY

Pericarp

Cross section.

Exocarp. This consists of thin cuticle and a layer of epidermal cells oblong-rectangular in shape or nearly so.

In surface view, the cells of the epidermis are polygonal in shape, and vary in size up to about 42 microns, long axis. Many small, rosette crystals of calcium oxalate occur in this tissue. Stomata are few, and surrounded by 3, 4, or 5 epidermal cells. The cuticle is smooth.

Mesocarp. This consists of tangentially elliptical or elongated parenchyma cells in the outer and inner mesocarp except where sclerenchymatous, reticulated cells flank the fibrovascular tissue.

Endocarp. This consists of a layer of thin-walled cells, tangentially elongated, narrow, except in the central commissural region where they are nearly quadrilateral in shape.

In surface view, the endocarp cells are transversely elongated, narrow, and vary in size up to about 90 microns, long axis, and up to 6 microns, short axis, except (a) in the central commissural region where the cells are longitudinally oblong-rectangular in shape, and vary in size up to about 68 microns, long axis, and to about 18 microns, short axis, and (b) in the basal commissural region where a number of transverse cells up to about 32 microns, long axis, and 9 microns, short axis, occur.

Fibrovascular Bundles. Five fibrovascular bundles traverse the outer mesocarp; 3 of these comprise the dorsal ridges and 2 the commissural ridges of the mericarp. The fibrovascular bundles are flanked on the outer side (above) by isodiametric, lignified, reticulated cells, and on the inner side (below) by tangentially elliptical, lignified, reticulated cells. Both spiral and reticulate vessels occur in the xylem tissue.

Vittae. There are usually 4 dorsal and 2 commissural vittae. Occasionally, however, branching of this tissue may result in 7, 8, or 9 vittae being seen in cross section. The vittae are yellowish-brown, elliptical, schizogenous, secretory cavities.

In surface view, the vittae are yellowish-brown, tubular tissues, sometimes branched, consisting of small, polygonal, cutinized cells; membranous cross walls occur at intervals.

Seed

Cross section.

Seed Coat. This consists of a layer of epidermal cells on the dorsal side, an epidermal layer and underlying parenchyma on the commissural side; the raphe is centrally situated in the latter tissue. The epidermal cells are tangentially oblong-rectangular; the parenchyma cells are tangentially elliptical except around the raphe where they are small and isodiametric or irregular in shape. The outer walls of the epidermal cells are cutinized.

In surface view, the epidermal cells are polygonal in shape. An inner, thin cuticle is present.

Endosperm. This consists of polygonal cells with moderately thick, colorless walls. The cell contents consist of aleurone grains and globules of fixed oil. There is a rosette crystal of calcium oxalate embedded in many of the larger aleurone grains.

Embryo. The embryo varies in length from about 1000 to 1300 microns, and consists of radicle and 2 cotyledons. It is embedded in the endosperm with the radicle toward the apex of the seed. The cells contain aleurone grains and globules of fixed oil.

Pedicel

Cross section.

Epidermis. This consists of a layer of cells oblong-rectangular in shape or nearly so, with moderately thick outer walls.

In surface view, the epidermal cells overlying the cortex collenchyma tissue are oblong-rectangular with somewhat thickened, pitted walls; there are no stomata. The epidermal cells overlying the cortex parenchyma tissue are polygonal in shape with thinner, faintly pitted walls; there are many stomata. The guard cells of the stomata are surrounded by 2, 3, or 4 epidermal cells with the first number predominant.

Cortex. This consists of parenchyma and collenchyma cells. The parenchyma cells immediately underlying the epidermis are palisade-like, the remainder are isodiametric or irregular in shape. The cell walls are thin. There are numerous chloroplasts in this tissue. The collenchyma cells fan out from the vittae to the epidermis. Soaking and bleaching is necessary to expand the tissues.

Vittae. There are 2 vittae; they are situated in the cortex.

Fibrovascular Tissue. A large, cylindrical mass of fibrovascular tissue forms the bulk and core of the pedicel.

Carpophore

The carpophore is a modified extension of the pedicel and is divided.

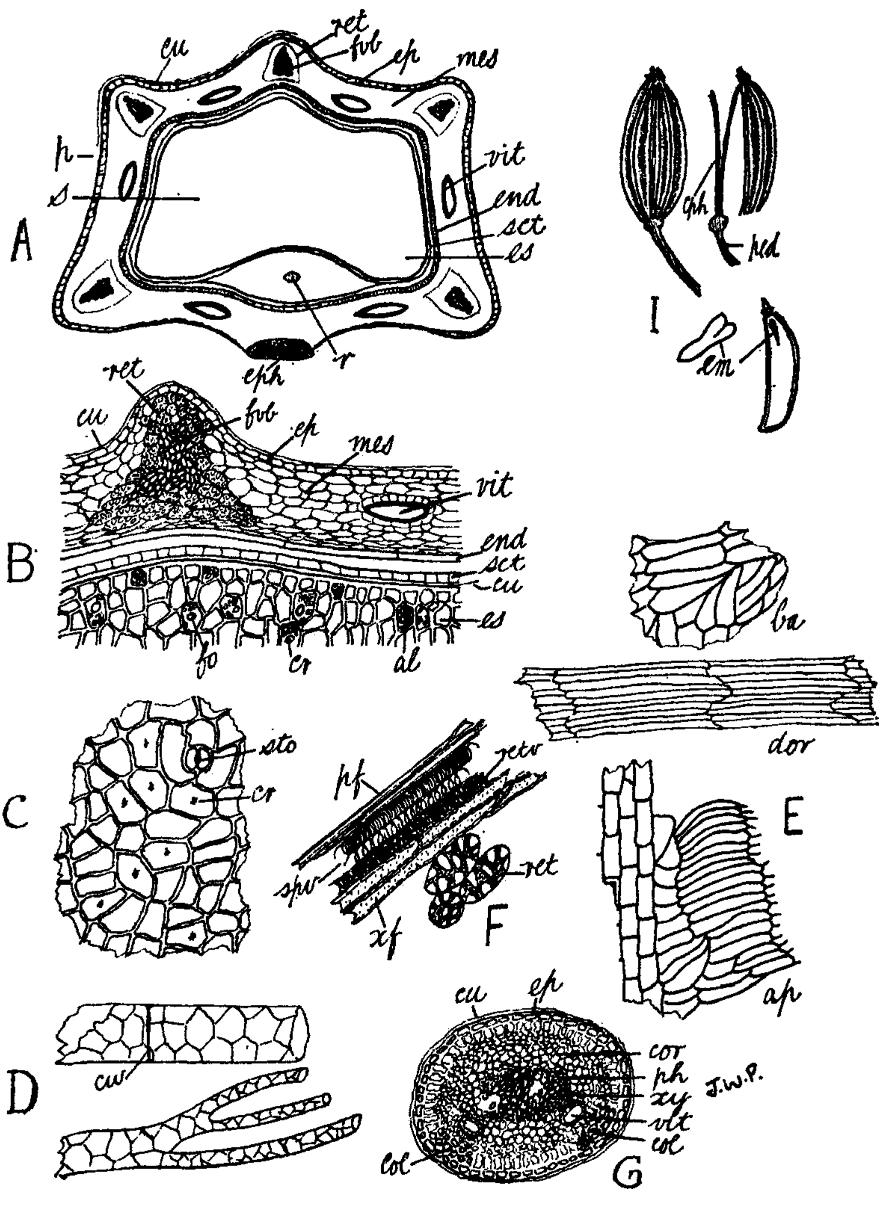

Fig. 25. FENNEL. I—Schizocarp (left); mericarp (right). (A) Cross section of mericarp. (B) Cross section through ridge. (C) Epidermis of pericarp, surface view. (D) Longitudinal view of vitta, simple and branched. (E) Endocarp, surface view. (F) Fibrovascular tissue and reticulated cells. (G) Cross section of pedicel.

al, aleurone; ap, apex; ba, base; col, collenchyma; cor, cortex; cph, carpophore; cr, crystal; cu, cuticle; cw, cross wall; dor, dorsal; em, embryo; end, endocarp; ep, epidermis; es, endosperm; fo, fixed oil; fvb, fibrovascular bundle; mes, mesocarp; p, pericarp; ped, pedicel; pf, phloem fibers; ph, phloem; r, raphe; ret, reticulated cells; retv, reticulated vessel; s, seed; sct, seed coat; spv, spiral vessel; sto, stoma; vit, vitta; xf, xylem fibers; xy, xylem.

Labiatae

GENERAL

The members of the Labiatae family included in this work are herbaceous or shrubby plants bearing simple, opposite leaves, and irregular, bilabiate flowers with 2 to 4 stamens and a deeply 4-loculed ovary; fruit of 4 achenes or nutlets.

XXVIII. SWEET MARJORAM

Majorana hortensis M.
Family: *Labiatae*

MORPHOLOGY

The commercial product consists of the dried leaves and floral parts of the plant; smaller leaves usually whole, larger leaves always broken. Leaves light green with a slight grayish tinge, obovate to broadly elliptical, margin entire, reaching about 21 mm in length, 11 mm in breadth; petiolate; net venation, pinnate; glandular punctate; pubescent. The dot-like oil glands and hairs visible with the aid of a good hand lens or the microscope.

Floral parts: Bract, light grayish-yellow, obovate, thin, reaching about 5.5 mm in length, 3.5 mm in breadth. Calyx gamosepalous, about 3 mm long, with 5 prominent teeth. Corolla sometimes present, gamopetalous, about 5 mm long; stamens 4, attached to corolla; style with bilobed stigma.

The odor of sweet marjoram is pleasant and aromatic; French marjoram is especially fragrant. The taste is warm, aromatic, slightly sharp, bitterish and somewhat camphoraceous.

HISTOLOGY

Leaf

Cross section. A thin cuticle covers the upper and lower epidermis. The cells of the upper and lower epidermis are nearly rectangular, the outer walls are thick, the inner walls are thin and arch inwardly. Small capitate hairs, oil glands sunken in depressions in the epidermis, and numerous thick-walled, papillose, pointed, nonglandular hairs, broad at the base, are present on both the upper and lower epidermis. The nonglandular hairs are uni- or multicellular with the latter type predominating. The multicellular hairs rarely exceed 4 cells, but an occasional hair with 5 cells occurs. The mesophyll consists of a single layer of palisade cells, and spongy tissue. Vascular tissue traverses the spongy mesophyll. The vascular bundle of the midrib is separated from the lower epidermis by 3 to 5 layers of collenchyma cells; a few collenchyma cells occur between the bundle and the upper epidermis.

In surface view, with the exception of the regions near and over the midrib and veins where the cells are more nearly rectangular and straight-walled, the cells of the upper and lower epidermis are irregular in shape and wavy-walled. The walls of the epidermal cells over the midrib are beaded, sometimes strongly; the walls of most of the other epidermal cells are faintly beaded. Stomata are few in the upper epidermis and abundant in the lower; the guard cells are surrounded by 2, 3, or 4 epidermal cells with the first number predominant. Nonglandular and glandular hairs occur on both sides of the leaf. The nonglandular hairs are described above; the capitate hairs (glandular) are small and have 1- or 2-celled stalks, they are not abundant. The oil glands are 12-celled and from about 65 to 75 microns in diameter.

Petiole

In cross section the petiole is somewhat crescent-shaped. The epidermal cells are rectangular or nearly so. Nonglandular and glandular hairs are present. Collenchyma tissue occurs in the corners, and a layer of collenchyma cells underlie the upper and lower epidermis. The vascular tissue occupies a central position in the mesophyll.

Flowering Tops

Bract. Cross section. The bract is thin and consists of (a) cuticle over each epidermis; (b) an upper epidermis of rectangular cells with outer walls about half as thick as those of the lower epidermis. A few stomata occur. Small capitate hairs are present but no oil glands or nonglandular hairs; (c) parenchymatous mesophyll tissue with chloroplasts; no palisade cells; (d) vascular tissue traversing the mesophyll; and (e) lower epidermis of rectangular cells with thick (7 to 10 microns) outer walls. Several stomata occur. Nonglandular hairs, capitate hairs, and oil glands are present. (Since the bract stands almost erect the lower is the outer epidermis, and the upper is the inner epidermis or that facing the calyx.)

In surface view, the epidermal cells of the bract are irregular and wavy-walled except over the midrib and at the base of the bract. Over the midrib the epidermal cells are oblong-rectangular and straight-walled; at the base they are vertically elongated and wavy-walled.

Calyx. The calyx is gamosepalous with 5 prominent teeth. The epidermal cells are irregular in shape and wavy-walled except at the base where they are oblong-rectangular and straighter-walled. On the outer epidermis, nonglandular and glandular hairs similar to those of the leaf occur. On the inner epidermis, small capitate hairs are present; the epidermal cells are mostly finely papillose, and numerous long, multicellular, papillose, pointed hairs arise from the throat region.

Corolla. The corolla is gamopetalous. The basal cells of the outer epidermis are vertically-elongated, wavy-walled between veins, nearly straight-walled over veins; the remaining epidermal cells are irregular in shape and wavywalled, papillose at the apexes of the lobes. The cells of the inner epidermis are similar to those of the outer but finely papillose from the higher basal region to the lobes. On the outer epidermis there are many short, uni- and multicellular papillose hairs, a few capitate hairs and oil glands. On the inner epidermis there are a few short, uni- and multicellular hairs, capitate hairs, and no oil glands.

Stamens and Pollen. The stamens are 4 in number. The epidermal cells of the anthers are papillose. The pollen grains are spherical but collapsed; about 20 to 22 microns in diameter.

Style. The style has a bilobe, papillose stigma.

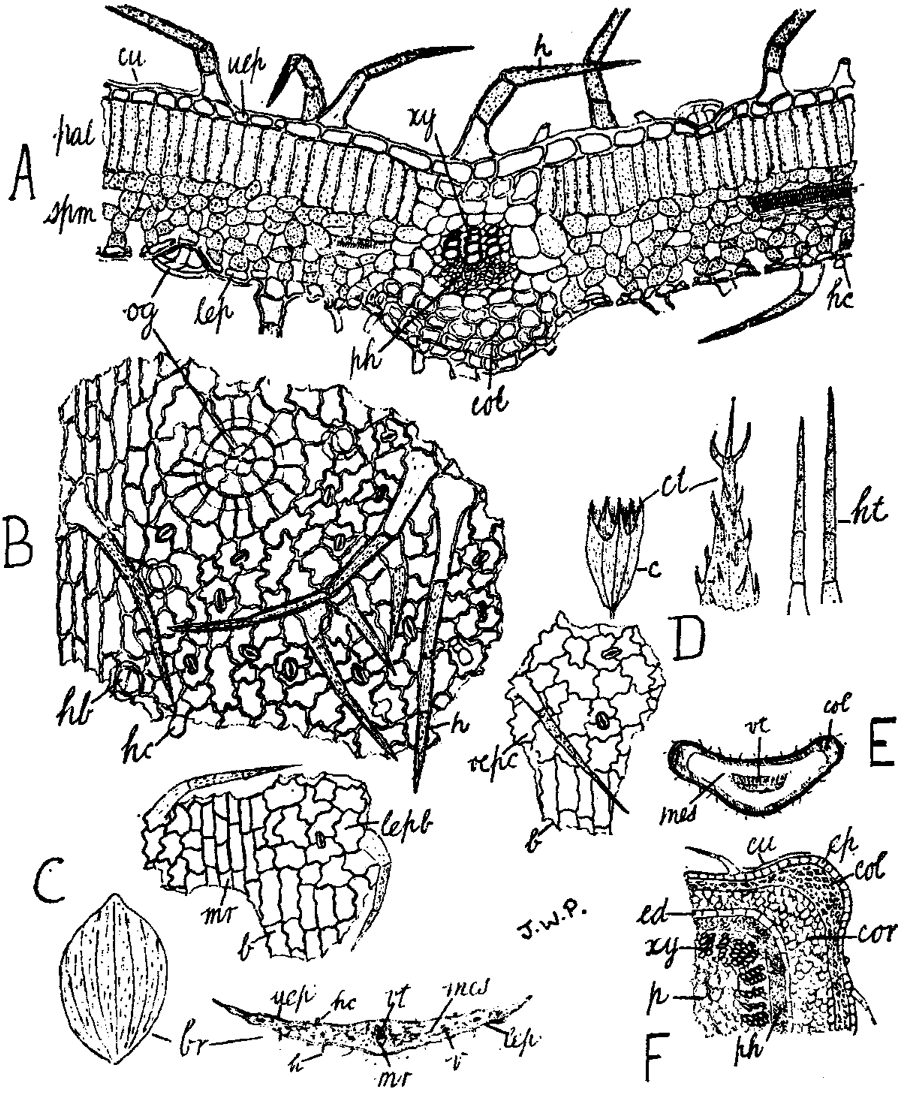

Fig. 26. SWEET MARJORAM. (A) Cross section through midrib. (B) Surface view of lower epidermis. (C) Bract; and cross section of bract (right); surface view of lower epidermis of bract (right, above). (D) Calyx; and surface view of outer epidermis of a calyx (below, left). (E) Cross section of petiole. (F) Cross section of corner of stem.

b, base; br, bract; c, calyx; col, collenchyma; cor, cortex; ct, calyx teeth; cu, cuticle; ed, endodermis; ep, epidermis; h, hair; hc, capitate hair; hb, hair base; ht, throat hairs; lep, lower epidermis; lepb, lower epidermis of bract; mes, mesophyll; mr, midrib; og, oil gland; oepc, outer epiderimis of calyx; pal, palisade cells; ph, phloem; p, pith; spm, spongy mesophyll; uep, upper epidermis; v, vein; vt, vascular tissue; xy, xylem.

XXIX. ORIGANUM

(Probably a variety of *Origanum vulgare*)
Family: *Labiatae*

[OREGANO, MEXICAN SAGE]

MORPHOLOGY

The commercial product consists of the dried leaves and floral parts of the plant; smaller leaves usually whole, larger leaves always broken. Leaves light green to greenish-brown, blade ovate, margin crenate to crenate-serrate, about 3 cm in length; petiolate; net venation, pinnate; glandular punctate; pubescent. The dot-like oil glands and hairs visible with the aid of a hand lens or the microscope.

Flowers crowded into spike-like clusters, bracts small, broadly ovate, imbricated, 2.5 to 3 mm long, 2 mm broad, hairs on the outer surface visible to the naked eye, hairs on the inner surface visible only with the microscope. Calyx small, gamosepalous, 4-toothed, deeply cleft on 2 sides, without throat hairs. Corolla much longer than the calyx, about 5 mm, gamopetalous; stamens 4, attached to corolla; style plumose.

Origanum has a strong, camphoraceous odor and a warm, pungent, bitter, camphoraceous taste.

HISTOLOGY

Leaf

Cross section. A thin cuticle covers the upper and lower epidermis. The epidermal cells are nearly rectangular except around the base of hairs where they are angular. The outer cell walls of the upper epidermis are thick. On both the upper and lower epidermis there are numerous curved, pointed, unicellular, nonglandular hairs, some papillose, others smooth; unicellular oil glands with very short unicellular stalks; very small, unicellular capitate hairs with multicellular stalks; and small, bicellular, biseriate glandular hairs with unicellular stalks. The mesophyll consists of a single layer of palisade cells, and spongy tissue. The vascular tissue traverses the spongy mesophyll. Collenchyma tissue separates the vascular bundle of the midrib and veins from the upper and lower epidermis. The midrib is large, and the veins are pronounced.

In surface view, the cells of the upper and lower epidermis are irregular, angular, or polygonal in shape, except over the midrib and veins where they are oblong-rectangular or nearly so. The cell walls are uneven in thickness, occasionally beaded near the midrib, veins and hairs, and strongly beaded over the midrib and veins. The nonglandular hairs vary in length to about 900 microns; the oil glands are about 40 microns in diameter; the gland cells of the biseriate hairs are elongated to about 32 microns; and the small capitate hairs have a glandular head about 22 microns in diameter. There are stomata on both sides of the leaf, sparse on the upper surface, numerous on the lower; the guard cells are surrounded by 2, 3, or 4 epidermal cells.

Petiole

In cross section, the petiole is somewhat crown-shaped. The cells of the epidermis are nearly rectangular. Numerous nonglandular and glandular hairs are present. Collenchyma tissue occupies the corners and underlies the upper and lower epidermis. On the sides of the petiole, parenchymatous palisade-like cells with chloroplasts underlie the epidermis. The mesophyll cells are isodiametric, oval, or elliptical in shape. The main vascular tissue occupies a central position in the mesophyll, and a small vascular bundle occurs in each upper corner of the petiole.

Flowering Tops

Bract. The epidermal cells of the bract are similar in shape and arrangement to those of the leaf. Nonglandular and glandular hairs occur. The nonglandular hairs are numerous on the outer epidermis, particularly at the margins; few on the inner. Stomata are present and they are similar to those of the leaf.

Calyx. The calyx is gamosepalous, small, 4-toothed, and deeply cleft on 2 sides. The cells and hairs of the outer epidermis are similar to those of the leaf and bract; there are no hairs on the inner epidermis.

Corolla. The corolla is gamopetalous; the corolla tube is long, the lobes are regular. The cells of the inner epidermis are irregular in shape; irregular and papillose toward and at the lobes. The cells of the outer epidermis of the corolla tube are oblong-rectangular in shape with straight, beaded walls; those of the outer epidermis of the lobes are irregular in shape with "looped" walls. Numerous nonglandular and glandular hairs occur on the outer epidermis of that portion of the corolla which extends beyond the calyx.

Stamens. The stamens are 4 in number and arise from the throat of the corolla. The outer epidermal cells of the anthers are papillose. The epidermal cells of the filaments are oblong-rectangular.

Pistil. The pistil consists of a 2-loculed ovary, style, and bilobed, spinose stigma. The bilobed nature of the stigma is obscured in a mass of prominent, short, spinelike cells among which remains of pollen grains are usually present. The pollen grains are spherical or nearly so, 3-ridged, and about 22 microns in diameter.

Stem

Cross section. The stem is square or nearly so. The cells of the epidermis are nearly rectangular; angular where hairs arise. Numerous hairs are present. There are about 3 layers of collenchyma cells in each corner, and 1 layer underlying the epidermis on each side of the stem. A broken ring of fibers and a few stone cells occur in the cortex. With the exception of about 3 layers of cells adjoining the phloem tissue, the cells of the cortex have brown contents. The fibrovascular tissue forms an unbroken ring around the pith. The cells of the pith are isodiametric; most are pitted.

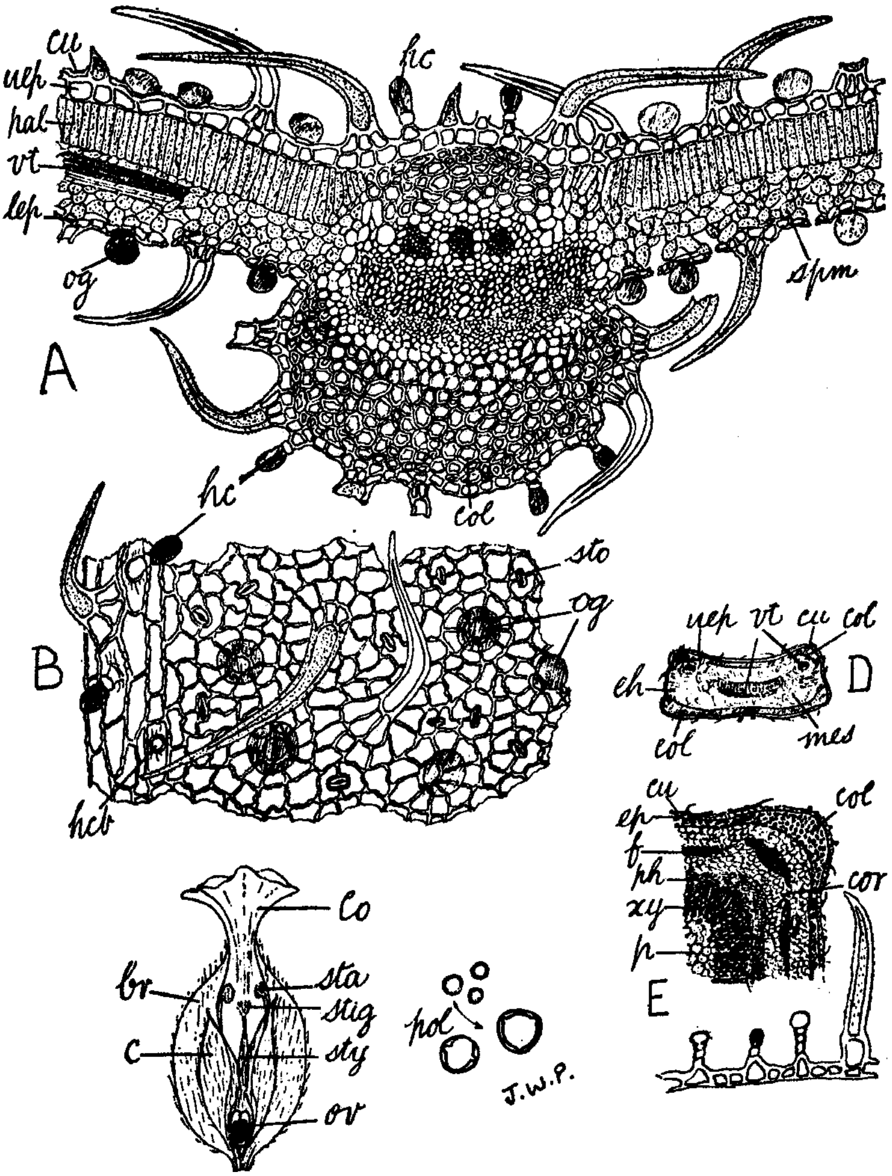

Fig. 27. ORIGANUM. (A) Cross section through midrib. (B) Lower epidermis, surface view. (C) Flower. (D) Cross section of petiole. (E) Cross section of corner of stem; below, stem hairs.

br, bract; c, calyx; ch, chloroplast cells; co, corolla; col, collenchyma; cor, cortex; cu, cuticle; ep, epidermis; f, fibers; hc, capitate hair; hcb, capitate hair base; lep, lower epidermis; mes, mesophyll; og, oil gland; ov, ovary; pal, palisade cells; ph, phloem; p, pith; pol, pollen; spm, spongy mesophyll; sta, stamen; stig, stigma; sto, stoma; sty, style; uep, upper epidermis; vt, vascular tissue; xy, xylem.

XXX. PEPPERMINT

Mentha piperita L.
Family: *Labiatae*

MORPHOLOGY

Dried leaves, whole, broken, crumpled, or shrivelled; dark green; mature leaf blade commonly about 45 mm in length, and about 23 mm in width; petiolate, ovate, margin serrate, apex acute, midrib prominent; net venation, pinnate; glandular punctate, the dot-like oil glands visible with hand lens; non glandular hairs present on the lower epidermis, occurring on the midrib, veins and at margin; a few nonglandular hairs on the upper epidermis, occurring on the midrib; hairs visible with the aid of a hand lens.

Floral parts: Calyx gamosepalous, purplish, small, about 3 mm long, glandular punctate, equally 5-toothed, teeth prominent and long, hairs arising from the calyx teeth but throat naked. Corolla sometime present, gamopetalous, stamens 4, style with bilobed stigma.

Odor characteristic, sweetish, strong; taste aromatic, warm, pungent, with a cooling aftertaste.

HISTOLOGY

Leaf

Cross section. A cuticle covers the upper and lower epidermis. The cells of the upper epidermis are nearly rectangular in shape, regular in arrangement, and have moderately thick outer walls. The cells of the lower epidermis are nearly rectangular, less regular, and have somewhat thinner walls than those of the upper epidermis. Oil glands, capitate hairs, uni- and multicellular nonglandular hairs occur on the lower surface; the nonglandular hairs arise from the epidermis over the midrib, veins, and at the margin of the leaf blade.

A few nonglandular hairs occur on the upper surface over the midrib. Nonglandular hairs do not occur on other parts of the leaf blade. The mesophyll consists of 1 layer of palisade cells, and spongy tissue. Vascular tissue traverses the spongy mesophyll. Between the lower epidermis and the vascular tissue of the midrib and veins there is a conspicuous group of collenchyma cells giving support, bulk and prominence to these parts.

In surface view, the cuticle is striated over the midrib, veins, and at the margins of the leaf; it is otherwise clear. With the exception of the regions near and over the midrib and veins, the cells of the upper epidermis are irregular in shape with wavy walls, and vary in size up to about 75 microns, long axis, with some irregular-elongated cells near the midrib reaching 90 microns. Near and over the midrib and veins the cells become oblong-rectangular or nearly so, with nearly straight, infrequently beaded walls. At the margins the cells become smaller, polygonal, with straight walls, some beaded. Over the teeth and at the apex the cell walls are slightly wavy. Stomata do not occur on the upper surface. The cells of the lower epidermis are similar to those of the upper but somewhat smaller. Stomata are numerous on the lower surface; the guard cells are surrounded by 2 epidermal cells. Numerous small crystals are contained in the cells of the upper and lower epidermis; they are more clearly observed with polarized light. The nonglandular hairs arising from the lower epidermis over the midrib are long, multicellular, commonly 5 or 6 cells, thick-walled, papillose, and pointed; those on the veins and at the margin are similar but shorter and with fewer cells, many having only 1 or 2 cells. The few hairs arising from the upper epidermis over the midrib are multicellular, papillose, but shorter and less robust than those of the lower surface. Capitate hairs and oil glands occur on both the upper and lower epidermis. The capitate hairs are small and of two kinds: those with an oval or spherical head, 15 to 20 microns in diameter, and a short, 1-celled stalk; and those with a head only slightly enlarged, and a longer, 2-celled stalk. The oil glands are large, about 65 to 75 microns in diameter; most have 8 cells, but glands with 10 or 12 cells occur. With polarized light, a crystal group is seen in many of these glands.

Petiole

In cross section, the petiole is somewhat crescent-shaped, the upper side concave. A thin cuticle covers the epidermis. The epidermal cells are rectangular and regular. Long, multicellular, nonglandular hairs are present. Collenchyma tissue occupies the corners and underlies the upper and lower epidermis. The mesophyll cells are isodiametric with moderately thick walls.

The main vascular tissue is central in the mesophyll, and a small vascular bundle is situated in each corner adjoining the collenchyma tissue.

Flowering Tops

Calyx. The calyx is gamosepalous with 5 prominent teeth. The cells of the outer and inner epidermis are irregular in shape and wavy-walled, except toward and at the base of the calyx tube where they are oblong-rectangular and straight-walled, or nearly so. Capitate hairs and oil glands occur on the outer epidermis. Prominent, uni- and multicellular, papillose, pointed, nonglandular hairs arise from the calyx teeth. There are no hairs of any kind on the inner epidermis. Vascular tissue traverses the mesophyll, 3 bundles merging in each tooth.

Corolla. The corolla is gamopetalous. The cells of the outer and inner epidermis are irregular in shape and papillose at the lobes; irregular in shape, wavy-walled, and finely papillose below the lobes; oblong-rectangular and wavy-walled in the region of the stamens; and oblong-rectangular and straight-walled toward and at the base of the corolla. On the outer epidermis there are capitate hairs, oil glands, and a few 1- or 2-celled, papillose, nonglandular hairs, all occurring on the lobes. There are no hairs of any kind on the inner epidermis. Vascular tissue traverses the mesophyll.

Stamens. The stamens are 4 in number, short, and similar. Crystals occur in the epidermal cells of the anthers. The pollen grains are spheroidal, and from about 25 to 35 microns in diameter.

Style and Stigma. The epidermal cells of the style are oblong-rectangular, and contain crystals. The stigma is bilobed and papillose.

Stem

Cross section. The stem is square. A thin cuticle covers the epidermis. The epidermal cells are nearly rectangular and regular. Occasional hairs occur. A group of collenchyma cells occupies and bulges each corner; a layer of collenchyma cells underlies the epidermis on all sides. The cells of the cortex are elliptical or oval with small intercellular spaces. An endodermis is present. A broken ring of fibers and fibrovascular tissue surrounds the pith. The pith consists of isodiametric, oval, or elliptical parenchyma cells with small intercellular spaces.

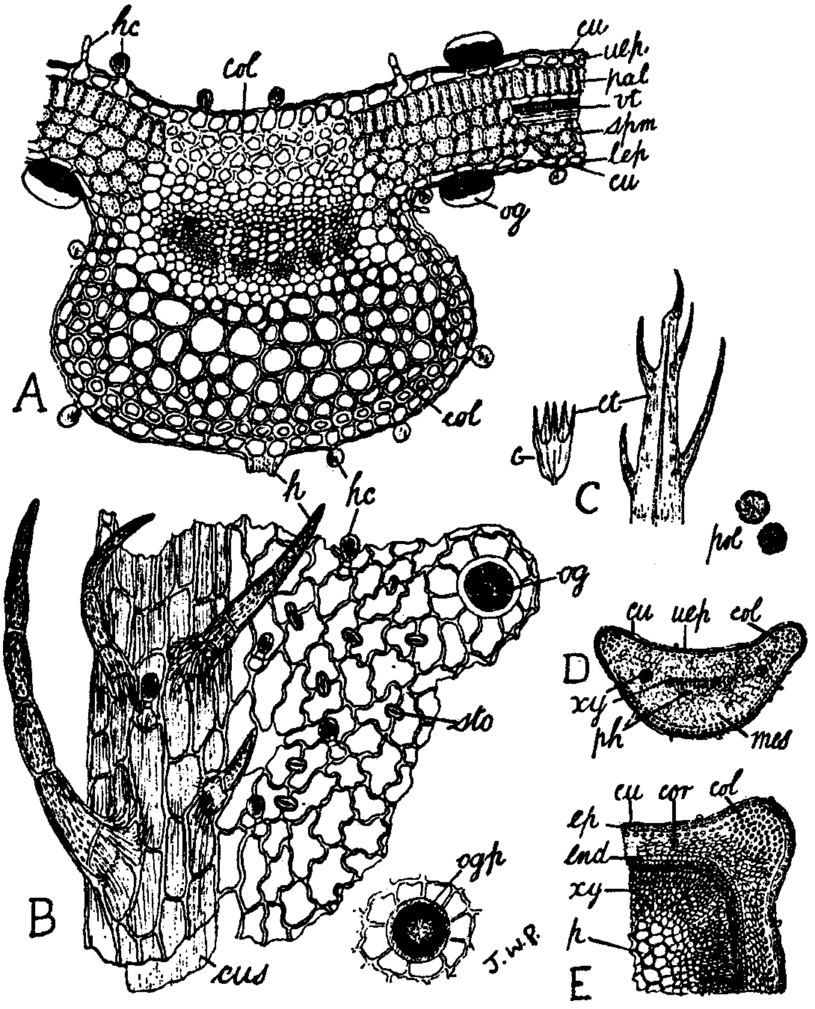

Fig. 28. PEPPERMINT. (A) Cross section through midrib. (B) Lower epidermis, surface view. (C) Calyx and calyx tooth. (D) Cross section of petiole. (E) Cross section of corner of stem.

c, calyx; col, collenchyma; cor, cortex; ct, calyx tooth; cu, cuticle; cus, cuticle, striated; end, endodermis; ep, epidermis; h, hair; hc, capitate hair; lep, lower epidermis; mes, mesophyll; og, oil gland; ogp, oil gland with crystals, polarized light; pal, palisade cells; p, pith; ph, phloem; pol, pollen; spm, spongy mesophyll; sto, stoma; uep, upper epidermis; vt, vascular tissue; xy, xylem.

XXXI. SPEARMINT

Mentha spicata L.
Family: *Labiatae*

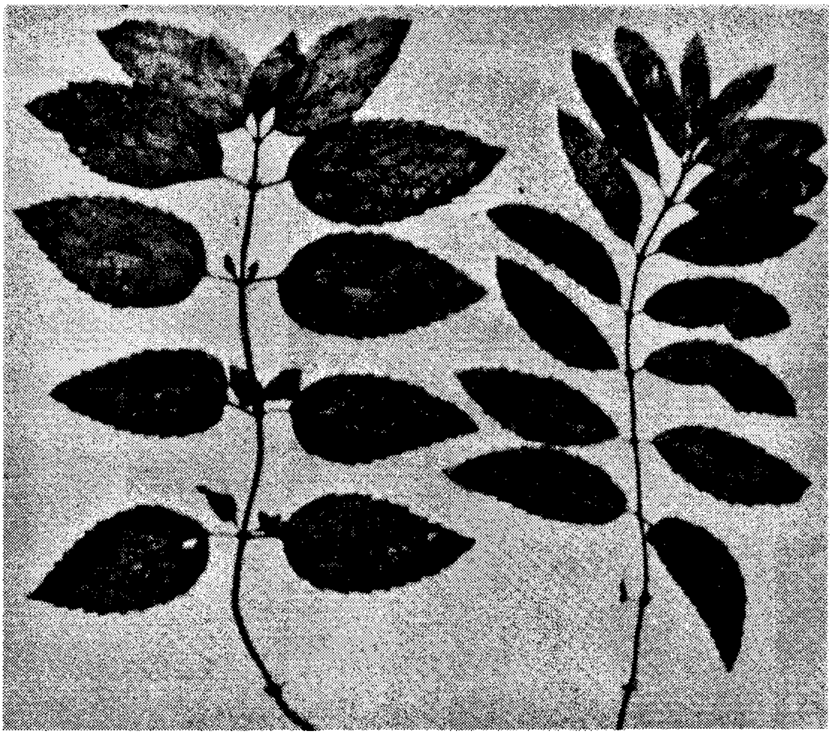

Fig. 29. PEPPERMINT (*left*), **SPEARMINT** (*right*).

MORPHOLOGY

Dried leaves, whole, broken, crumpled, or shrivelled; olive green; mature leaf blade commonly about 35 mm long, and about 13 mm wide; petiole very short, about 2 to 4 mm long; blade lance-ovate to elliptical, margin unequally serrate, apex acute, midrib prominent; net venation, pinnate; glandular punctate, the dot-like oil glands visible with hand lens; a few nonglandular hairs on the lower surface of the leaf blade arising from the epidermis over the midrib, some occurring at the margin near the teeth; hairs not visible without the aid of the microscope; no nonglandular hairs on the upper surface.

Floral parts similar to those of peppermint.

Odor and taste similar to that of peppermint but to a leasser degree; no cooling aftertaste.

HISTOLOGY

The histological structure of spearmint is similar to that of peppermint. The chief differences, and these are probably more morphological than histological, lie in the leaves and are (a) the absence of nonglandular hairs on the upper epidermis; (b) fewer, and shorter, nonglandular hairs on the lower surface over the midrib, with few, if any, over the veins; and (c) the absence of crystals in the oil glands.

XXXII. ROSEMARY

Rosmarinus officinalis L.
Family: *Labiatae*

MORPHOLOGY

Dried leaves, brownish-green, sessile, linear, slightly curved, margins revolute, from about 6 to 25 mm long, midrib prominent, glandular-punctate, lower surface wooly except over the midrib but concealed by marginal curling of the leaf.

No floral parts are present.

Rosemary leaves have a tea-like fragrance. When crushed they yield an agreeable, aromatic odor with a slight camphoraceous note. The taste is aromatic, pungent, somewhat bitter and slightly camphoraceous.

HISTOLOGY

Leaf

Cross section. The cells of the upper epidermis are compressed, small, and inconspicuous; cuticle wrinkled. Unless the section has been well soaked in water, or the cells expanded with the aid of bleaching solution, it is possible to overlook the existence of the upper epidermis in cross section. Remains of occasional hairs occur on the upper epidermis. Collenchyma tissue forms a thick-walled hypodermal layer underlying the upper epidermis, and wedge-shaped pockets of collenchyma cells separate groups of mesophyll cells. The palisade cells are up to about 80 microns, long axis, and form 1 to 3 layers. Spongy tissue completes the mesophyll. A dense, tangled mass of branched, multicellular, smooth hairs covers the lower epidermis. The branches of the hairs are curved and pointed. Some hairs give rise to a bulbous, glandular branch. Capitate hairs and 8-celled oil glands are also present. The lower

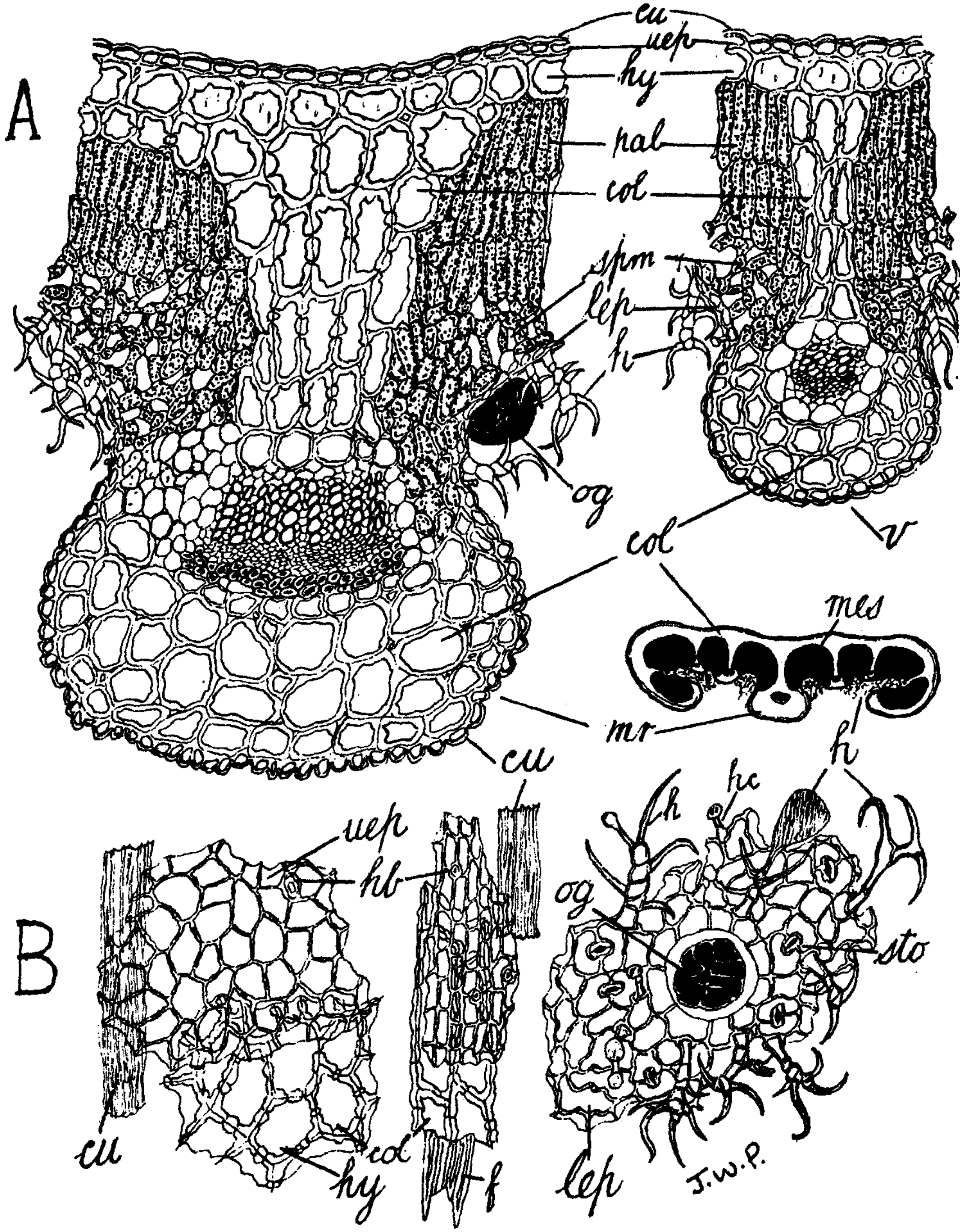

Fig. 30. ROSEMARY. (A) Cross section through midrib (right); through vein (far right); cross section of leaf (below). (B) Upper epidermis (right); lower epidermis of midrib (center); lower epidermis (far right); all in surface view.

col, collenchyma; cu, cuticle; f, fibers; h, hair; hc, capitate hair; hb, hair base; hy, hypodermis; lep, lower epidermis; mes, mesophyll; mr, midrib; og, oil gland; pal, palisade cells; spm, spongy mesophyll; sto, stoma; uep, upper epidermis; v, vein.

epidermis and its cuticle are closely wrinkled at the midrib. The midrib is prominent; the fibrovascular bundle is separated from the hypodermis by a wedge-shaped group of collenchyma cells, and from the lower epidermis by 3 or 4 layers of collenchyma cells. The vessels are arranged in radial rows. Thick-walled fibers adjoin the phloem tissue. The vascular tissue of the veins is surrounded by a parenchymatous sheaf, and separated from the hypodermis by a wedge-shaped group of collenchyma cells, and from the lower epidermis by isodiametric or irregular-shaped collenchyma cells.

In surface view, the cells of the upper epidermis are polygonal in shape; the walls are of uneven thickness and beaded. There are no stomata. The collenchyma cells are large, up to about 110 microns, long axis, and polygonal in shape with thick, beaded walls. The cells of the lower epidermis are similar in shape to those of the upper but slightly larger; the walls are somewhat thinner and not so clearly beaded. The epidermal cells over the midrib are oblong-rectangular in shape and straight-walled. Stomata are frequent on the lower surface; the guard cells are surrounded by 2 epidermal cells.

Stem

Only occasional pieces of stem are present. The anatomy of the stem is similar to that of other labiate plants described in this work. An endodermis consisting of cells averaging about 10 microns in width, and about 26 microns, radial axis, is present. The vascular tissue of the stem is abundant and forms a complete ring around the pith. The pith cells have thick, pitted walls.

XXXIII. SAGE

Salvia officinalis L.
Family: *Labiatae*

MORPHOLOGY

Sage, Domestic

Leaves grayish-green, oblong-lanceolate, reaching about 8.5 cm in length, 2.5 cm in breadth, petiolate, apex acute, margin finely crenate; net venation, pinnate-reticulate; densely pubescent but not wooly; soft and velvety in texture; glandular-punctate, but glands obscured by hairs, visible only with the microscope.

Odor aromatic, strongly so when the leaves are crushed; taste aromatic and somewhat bitter.

Sage, Dalmatian

Dried leaves, whole, broken, or crushed; gray, tinged with green; wide variation in size; apex acute or obtuse; densely pubescent, wooly; otherwise as Domestic sage.

Odor strong, fragrant and aromatic; taste aromatic, warm, somewhat astringent and a little bitter.

Sage, Cyprus

Dried leaves, grayish-green to dark gray; hard, brittle; pubescent but not wooly; otherwise as Dalmatian sage.

Odor fragrant, aromatic, and somewhat camphoraceous; taste faintly aromatic, a little bitter, and somewhat camphoraceous.

Sage, Spanish

Dried leaves, dark gray; whole leaves usually small; not so wooly as Dalmatian sage, but otherwise as that product.

Odor aromatic with a camphoraceous note; taste warm, a little bitter, somewhat astringent and camphoraceous.

HISTOLOGY

Sage, Dalmatian

Leaf. Cross section. A cuticle, well-developed over the midrib, covers the epidermis. The cells of the upper and lower epidermis are rectangular or nearly so, but somewhat irregular over the midrib. Numerous nonglandular hairs, capitate hairs, and oil glands occur on both surfaces. The nonglandular hairs are uni- or multicellular with the latter type predominating. The multicellular hairs are very long, narrow, pointed, mostly smooth but some papillose, clear or with dark contents, and form a tangled mass. The capitate hairs have a bicellular, biseriate head and unicellular stalk, or a unicellular head and multicellular stalk. The midrib is prominent; its vascular bundle is large, and separated from the upper and lower epidermis by parenchyma and well-developed collenchyma tissue. Collenchyma is also present above and below the vascular tissue of the veins but to a lesser degree. The vascular tissue of the veins is surrounded by a parenchymatous sheaf. The mesophyll consists of from 1 to 3 layers of palisade cells, and spongy tissue.

In surface view, the cells of the upper epidermis are polygonal or irregular in shape with nearly straight, moderately thick, beaded walls. A few stomata are present. The cells of the lower epidermis are irregular in shape with nearly straight, or somewhat wavy walls, some beaded; the walls are slightly thinner than those of the upper epidermis. Stomata are numerous; the guard cells are surrounded by 2 or 3 epidermal cells, the former predominating. The oil glands have 8 to 12 cells. A study of the oil glands of Dalmatian sage is rendered difficult by the tangled mass of hairs surrounding them. The walls of the cells of the glands are very thin and easily obscured by the density of the oil. The nature of the glands is better seen in Spanish sage where the hairs are much shorter and the glands more completely visible. Clearing the oil with the aid of alcohol or other solvent is not much help; a weak, about 10 per cent, bleaching solution is better. Sections should be left in this solution for several hours or overnight. This treatment will generally clear the glands making a study of the thin walls of their cells possible.

Petiole. Cross section. The epidermal cells are rectangular or nearly so. Numerous nonglandular and glandular hairs are present. Collenchyma tissue occupies the corners and underlies the epidermis. The cells of the mesophyll are isodiametric, and vary in size to about 50 microns. The main fibrovas-

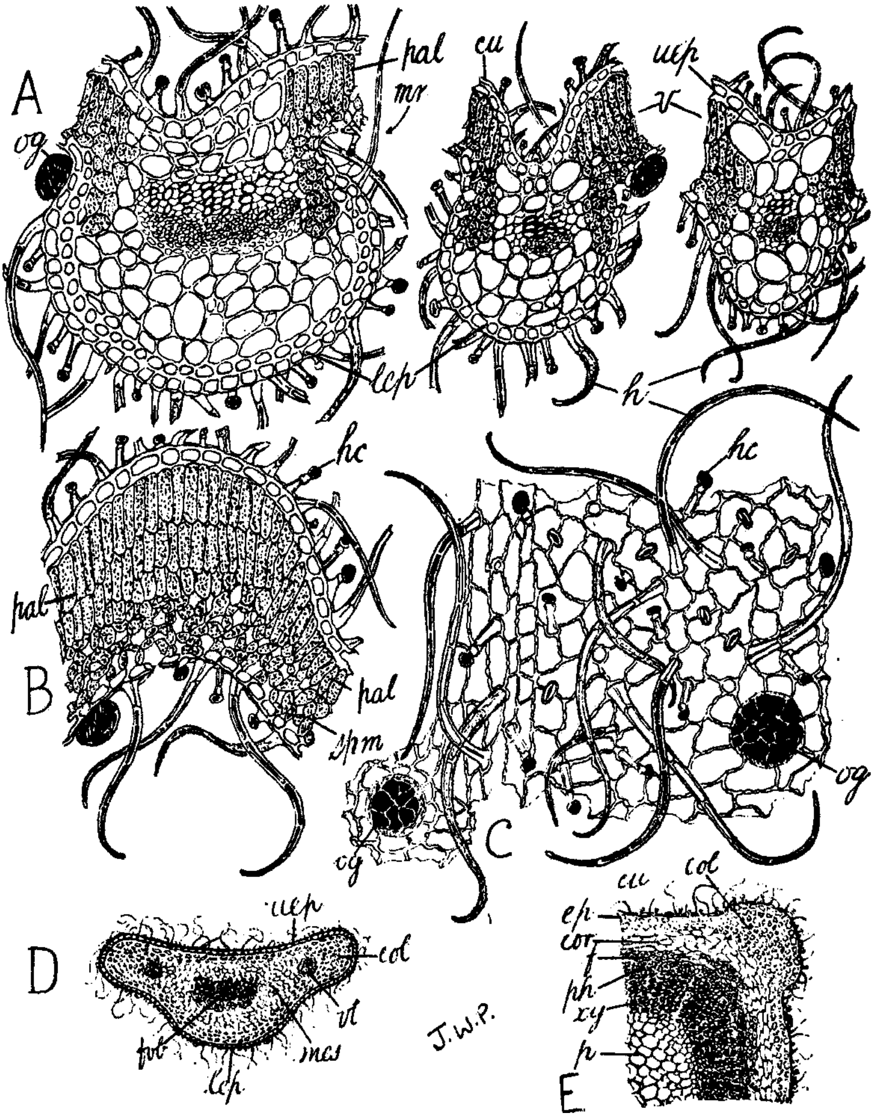

Fig. 31. SAGE. (A) Cross section through midrib; cross sections of a larger and a smaller vein at right. (B) Cross section of a portion of leaf blade. (C) Lower epidermis, surface view; (D) Cross section of petiole. (E) Cross section of corner of stem.

col, collenchyma; cor, cortex; cu, cuticle; ep, epidermis; f, fibers; fvb, fibrovascular bundle; h, hair; hc, capitate hair; lep, lower epidermis; mes, mesophyll; mr, midrib; og, oil gland; pal, palisade cells; p, pith; ph, phloem; spm, spongy mesophyll; uep, upper epidermis; v, vein; vt, vascular tissue; xy, xylem.

cular bundle is large, and occupies a central position in the mesophyll. A small fibrovascular bundle adjoins the collenchyma tissue in each corner.

Flowering Tops. Floral parts are not present in the product.

Stem. Cross section. The stem is square. The epidermal cells are rectangular or nearly so. Numerous nonglandular and glandular hairs are present. Collenchyma tissue occupies the 4 corners and underlies the epidermis on all sides of the stem. The cortex consists of thin-walled parenchyma cells. A broken ring of fibers, and an unbroken ring of fibrovascular tissue surrounds the pith. The cells of the pith are isodiametric, thin-walled, and up to about 110 microns in diameter.

Sage, Cyprus

The histological structure of Cyprus sage is similar to that of Dalmatian sage but the nonglandular hairs are fewer, somewhat thicker, and much shorter. Many of the capitate hairs are longer than those of Dalmatian sage.

Sage, Spanish

Spanish sage is anatomically similar to the Dalmatian product but the nonglandular hairs are shorter. The capitate hairs are fewer in number.

XXXIV. SAVORY

Satureia hortensis L.
Family: *Labiatae*

MORPHOLOGY

Dried leaves, greenish-brown, small, reaching about 10 mm in length; shape oblanceolate with acute tip, or spatulate with obtuse tip; tapering to short petiole; mostly folded upwards along the midrib; margin entire; net venation, pinnate; glandular punctate; pubescent. The dot-like oil glands and the hairs are visible with hand lens.

Floral parts: Calyx gamosepalous, 3 to 4 mm long; upper lobe with 3 teeth, short, united; lower lobe with 2 teeth, awl-like, deeply cleft; throat hairy. Corolla sometimes present, gamopetalous, about 4 to 5 mm long; stamens 4, didynamous; style with bilobed stigma.

Odor fragrant and aromatic; taste aromatic, warm, slightly sharp and somewhat camphoraceous.

HISTOLOGY

Leaf

Cross section. A thin cuticle covers the epidermis. The cells of the upper and lower epidermis are rectangular in shape or nearly so. Nonglandular hairs, capitate hairs; and oil glands are present. The midrib is not prominent. The fibrovascular bundle of the midrib is surrounded by a parenchymatous sheaf, and separated from the upper epidermis by parenchyma and collenchyma cells, and from the lower epidermis by parenchyma cells. The mesophyll consists of 2 layers of palisade cells, and spongy tissue with small intercellular spaces. It should be observed that the cells of the spongy mesophyll closely resemble those of the palisade mesophyll, and are very closely packed.

In surface view, the cells of the upper and lower epidermis are irregular in shape, and vary in size to about 88 microns, long axis; the cell walls are beaded. Uni- and multicellular, papillose, pointed hairs with dark contents, capitate hairs, and oil glands, occur on both sides of the leaf but are more numerous on the upper surface. The capitate hairs have a unicellular stalk. The oil glands are 12-celled, large, from about 88 to 96 microns in diameter, and are sunken in depressions in the epidermis. Stomata occur on both surfaces of the leaf; the guard cells are surrounded by 2 epidermal cells.

Petiole

In cross section, the petiole is somewhat crescent-shaped. The epidermal cells are rectangular or nearly so; hairs are present. Collenchyma cells occupy the corners, and a layer of collenchyma cells underlie the upper and lower epidermis. The cells of the mesophyll are isodiametric, oval, or elliptical, and up to about 44 microns, diameter or long axis. The fibrovascular tissue occupies a central position in the mesophyll.

Flowering Tops

Calyx. The calyx is gamosepalous, 5-toothed, and large. Two of the five teeth are prominent, long, and deeply cleft; the remaining three are short and shallowly cleft, united. Stiff, pointed hairs occur on the teeth. Nonglandular hairs, capitate hairs, and oil glands are present on the outer epidermis. Numerous, long, multicellular, papillose, pointed hairs arise from the calyx throat. The cells of the inner epidermis in the region of the throat hairs are finely papillose.

Corolla. The corolla is gamopetalous. In surface view, the outer and inner epidermal cells are oblong-rectangular in shape and straight-walled in the basal region of the corolla tube, oblong-rectangular or irregular with somewhat wavy walls in the lower lobal region, irregular and wavy-walled in the lobal region, and irregular and papillose at the apexes of the lobes. Small, prismatic crystals are seen in the cells of the lobes when examined with polarized light. Nonglandular hairs, capitate hairs, and oil glands occur on the outer epidermis of the corolla where it extends beyond the calyx. There are no hairs of any kind on the inner epidermis.

Stamens and Style. The stamens are 4 in number and didynamous. The pollen grains are spheroidal and vary in size from about 28 to 42 microns; they are granular and have 6 furrows. The style has a bilobed, papillose stigma.

Stem

Cross section. The stem is square or nearly so. Hairs similar to those

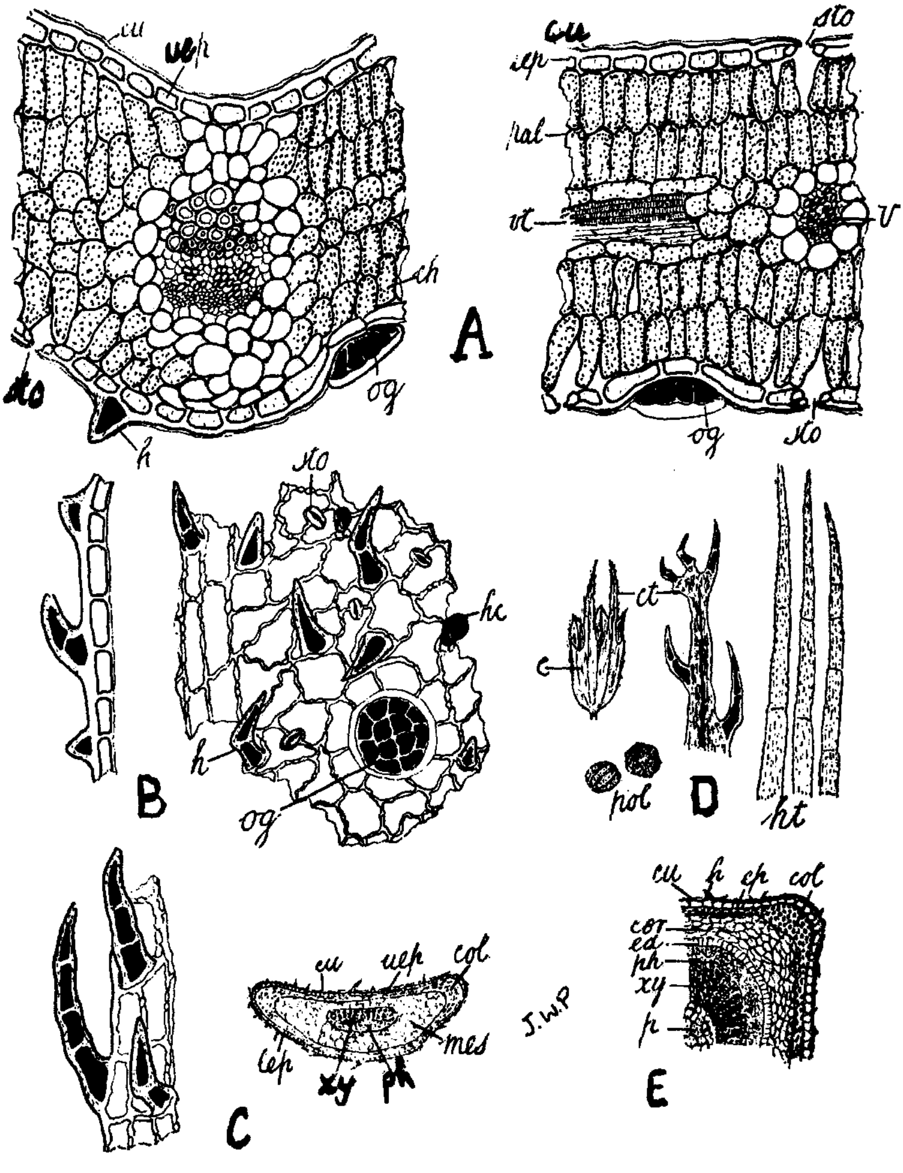

Fig. 32. SAVORY. (A) Cross section through midrib (left); through a portion of leaf blade (right). (B) leaf margin (left); lower epidermis, surface view (right). (C) Cross section of petiole (above, right); surface view of epidermis of petiole (left). (D) Calyx, calyx tooth, and throat hairs. (E) Cross section of corner of stem.

c, calyx; ch, chloroplasts; col, collenchyma; cor, cortex; ct, calyx tooth; cu, cuticle; ed, endodermis; ep, epidermis; h, hair; hc, capitate hair; ht, throat hairs; lep, lower epidermis; mes, mesophyll; og, oil gland; pal, palisade cells; p, pith; ph, phloem; pol, pollen; sto, stoma; uep, upper epidermis; v, vein; vt, vascular tissue; xy, xylem.

already described occur on the epidermis. The epidermal cells are rectangular or nearly so. Collenchyma cells occupy the corners, and a layer of collenchyma tissue underlies the epidermis on all sides of the stem. An endodermis separates the cortex from the vascular tissue. The fibrovascular tissue forms an unbroken ring around the pith. The pith consists of pitted cells up to about 88 microns in diameter.

XXXV. SWEET BASIL

Ocimum basilicum L.
Family: *Labiatae*

GENERAL

Several varieties of this herb find their way into commerce, including the small leaves of the common basil, the larger leaves of the purple leaf basil, the Italian basil, and the lettuce leaf basil. The large lettuce leaf has a mild aroma while the common basil with its very small leaf is very pungent. The larger leafed varieties are more commonly cultivated in the United States of America.

American producers of sweet basil prepare the commercial product by dehydrating the fresh leaves with controlled artificial heat and air. This process is carefully carried out to preserve color and aroma. The leaves may also be dehydrated by drying them in the sun but with this method precautions must be taken against night moisture. Fragmentation of the dried leaves is accomplished mechanically. A series of machines mill, brush, shake, blow and screen the leaf particles through specified size aperatures. The dried, fragmented herb is graded fine, medium, and coarse, enabling spice merchants to offer selective sizes suitable to the needs of their customers and consumers.

MORPHOLOGY

Leaves ovate, tip acute, petiolate; green; small leaves from about 1 to 5 cm, large leaves reaching about 10 cm in length; margin of small leaves finely serrate, that of large leaves indistincly serrate; net venation, pinnate; glandular punctate; slightly pubescent. The dot-like oil glands and the hairs are visible with a hand lens.

Floral parts: Calyx large, reaching about 7 mm, gamosepalous, irregular, and consisting of (a) lower lobe with twin awl-like teeth; (b) 2 upper lobes, deeply cleft, each with a short tooth; and (c) a large, broadly cordate labiate lobe. Calyx throat and inner surface of labiate lobe hairy. Corolla sometimes present; gamopetalous, longer than calyx; stamens 4, didynamous; style with bilobed stigma.

The dried leaves of the large leafed varieties of sweet basil have an aromatic, fragrant and sweet odor faintly reminiscent of anise. The taste is aromatic, warm, and mildly pungent. The dried leaves of the common basil have a less fragrant odor and are more pungent.

HISTOLOGY

Leaf

Cross section. A thin cuticle covers the epidermis on both sides of the leaf. The cells of the upper and lower epidermis are similar and nearly rectangular except where hairs and glands arise. The outer walls of the cells of the upper epidermis are thicker than those of the lower epidermal cells. Nonglandular, pointed hairs, capitate hairs, and oil glands occur on both surfaces of the leaf. A single palisade layer underlies the upper epidermis. The palisade cells are up to about 88 microns, long axis, and have an average width of about 22 microns. Spongy tissue completes the mesophyll. The vascular tissues traverse the spongy mesophyll.

The vascular tissue of the midrib and large veins is separated from the upper and lower epidermis by parenchyma and collenchyma tissues. The vascular tissue of the small veins is surrounded by a parenchymatous sheaf; a few collenchyma cells sometimes occur between the sheaf and the lower epidermis.

In surface view, the upper and lower epidermal cells are irregular in shape and wavy-walled except near and over the veins where they are nearly rectangular, and over the midrib where they are oblong-rectangular and straight-walled. The walls of the cells over the midrib are faintly beaded. Stomata occur in both the upper and lower epidermis; the guard cells are surrounded by 2 epidermal cells.

Nonglandular, uni- and multicellular, papillose, pointed hairs occur on both sides of the leaf but they are more numerous on the upper side. They arise from the epidermis of the midrib, large veins, and leaf margins.

The capitate hairs have a very short stalk, usually less than 10 microns, and a bicellular, biseriate head about 35 microns in diameter. The oil glands have 4 cells, and are about 80 microns in diameter. They occur on both the upper and lower epidermis but are more numerous on the lower.

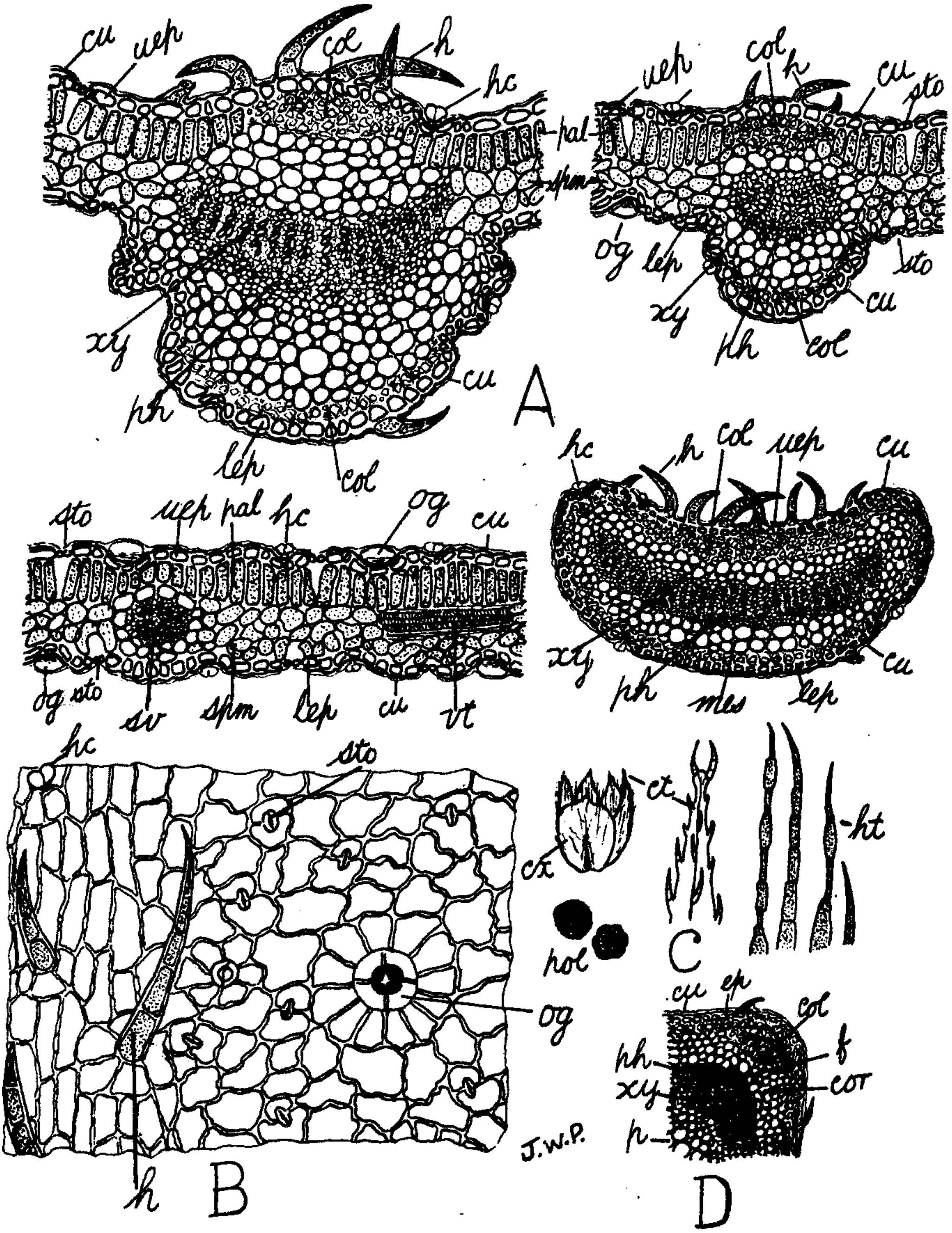

Fig. 33. SWEET BASIL. (A) Cross section through midrib (upper left); through a large vein (upper right); through a portion of the leaf blade (lower left); through the petiole (lower right). (B) Surface view of a portion of the upper epidermis. (C) Calyx with a view of a calyx tooth, throat hairs, and pollen. (D) Cross section through a corner of stem.

col, collenchyma; cor, cortex; ct, calyx teeth; cu, cuticle; cx, calyx; ep, epidermis; f, fibers; h, hair; hc, capitate hair; ht, throat hairs; lep, lower epidermis; mes, mesophyll; og, oil gland; p, pith; pal, palisade cells; ph, phloem; pol, pollen; spm, spongy mesophyll; sto, stoma; sv, small vein; uep, upper epidermis; vt, vascular tissue; xy, xylem.

Petiole

Cross section. The petiole is somewhat crescent-shaped. Nonglandular and glandular hairs are present. A layer of collenchyma tissue underlies the epidermal cells. The cells of the mesophyll are isodiametric and up to about 45 microns. A crescent-shaped group of xylem and phloem cells occupies a central position in the mesophyll.

Flowering Tops

Calyx. The calyx is gamosepalous with a broadly cordate, strongly veined, labiate lobe, very hairy on the surface toward the calyx tube. The calyx teeth are prominent and give rise to stiff, papillose hairs, uni- or multicellular with the latter predominating. Nonglandular hairs, capitate hairs, and oil glands occur on the outer epidermis. Capitate hairs and oil glands occur on the inner epidermis, and numerous long, multicellular, faintly papillose hairs arise from the throat of the calyx. In surface view, the cells of the inner and outer epidermis are small and wavy-walled; stomata are present.

Corolla. The corolla is gamopetalous. In surface view, the epidermal cells toward and at the base of the corolla tube are rectangular and straight-walled; toward the lobes they are oblong-rectangular and wavy-walled, and those of the lobes are small, irregular in shape and wavy-walled. Small, prismatic crystals occur in the lobe cells. Oil glands and numerous multicellular, faintly papillose hairs are present on the outer epidermis of the corolla.

Stamens and Style. The stamens are 4 in number and didynamous. The epidermal cells of the anthers are papillose and contain rosette crystals of calcium oxalate. The pollen grains are spherical with 6 divisions; they vary in size from about 45 to 55 microns. The style has a bilobed, papillose stigma.

Stem

Cross section. The stem is square or nearly so. The epidermal cells are rectangular. Hairs and oil glands are present. Collenchyma cells occupy the corners, and a layer of collenchyma tissue underlies the epidermis on all sides of the stem. The cortex cells are isodiametric and up to about 66 microns. A broken ring of fibrovascular tissue surrounds the pith. The pith consists of thin-walled, isodiametric cells up to about 88 microns.

XXXVI. THYME

Thymus vulgaris L.
Family: *Labiatae*

MORPHOLOGY

Dried leaves, greenish-brown, grayish on lower surface; small, reaching about 9 or 10 mm at most; ovate lanceolate, margin revolute, apex acute, petiolate; net venation, but obscure; glandular punctate; pubescent. The dot-like oil glands and hairs visible with a hand lens.

Floral parts: Calyx small, about 3 or 4 mm long, gamosepalous, upper lobe with 3 short teeth, lower lobe with 2 long, awl-like teeth deeply cleft; calyx throat hairy. Corolla frequently present, gamopetalous, 5 or 6 mm long, bilabiate; stamens 4, didynamous; style with bilobed stigma.

Odor fragrant and aromatic, accentuated when the leaves are crushed; taste aromatic, warm, and pungent.

HISTOLOGY

Leaf

Cross section. A cuticle occurs on both surfaces. The cells of the upper and lower epidermis are rectangular or nearly so; some pitting occurs in the cells of the upper epidermis. Nonglandular and glandular hairs are present. The nonglandular hairs are uni- or multicellular (most consist of 1 or 2 cells, but 3-cell hairs occur occasionally), thick-walled, strongly papillose with the exception of the basal cell of the multicellular hairs, some curved but mostly straight and stiff, pointed, clear or with dark contents. The capitate hairs have either 1- or 2-celled stalks. The mesophyll consists of 1 to 2 layers of palisade cells which vary in size, some reaching 90 microns, long axis, and spongy tissue with large intercellular spaces. Fibrovascular tissue traverses the spongy mesophyll. Numerous fibers are associated with the xylem and phloem of the midrib and veins. There is no collenchyma tissue.

In surface view, the epidermal cells of both sides of the leaf are irregular in shape with wavy walls except over the midrib and veins where the cells are rectangular and the walls straight. Stomata are few in the upper epidermis, abundant in the lower; the guard cells are surrounded by 2, 3, or 4 epidermal cells, with the 2-cell arrangement predominant. The capitate hairs are small, up to about 18 microns diameter. The oil glands are large, about 65 microns diameter, and 12-celled.

Petiole

Cross section. The epidermal cells are rectangular or nearly so. Hairs and oil glands are present. Collenchyma tissue occupies the corners and also forms a layer under the lower epidermis. Collenchyma tissue occurs between the fibrovascular bundle and the upper epidermis, but does not form a continuous layer under the upper epidermis. The fibrovascular tissue occupies a central position in the mesophyll.

Flowering Tops

Calyx. The calyx is gamosepalous, 5-toothed, and small. Two of the teeth are deeply cleft, project in prong-like fashion, and are prominent. Nonglandular and glandular hairs similar to those of the leaf occur on the outer epidermis. Numerous, long, multicellular, papillose hairs arise from the calyx throat. The inner epidermal cells in the region of the throat hairs are finely papillose.

Corolla. The corolla is gamopetalous. The apex epidermal cells of the lobes are papillose. Nonglandular and glandular hairs occur on the outer epidermis.

Stamens and Style. The stamens are 4 in number and didynamous. The epidermal cells of the anthers are papillose. The pollen grains are granular, have 6 furrows, and are spheroidal with diameter from 28 to 35 microns. The style has a bilobed stigma with papillose epidermal cells.

Stem

Cross section. The stem is square or nearly so. The epidermal cells are rectangular or nearly so. Nonglandular and glandular hairs are present. Collenchyma tissue occupies the corners and underlies the epidermis on all sides of the stem. The cortex cells are irregular in shape and thin-walled. The fibrovascular tissue forms an unbroken ring around the pith. The cells of the pith are thick-walled and pitted.

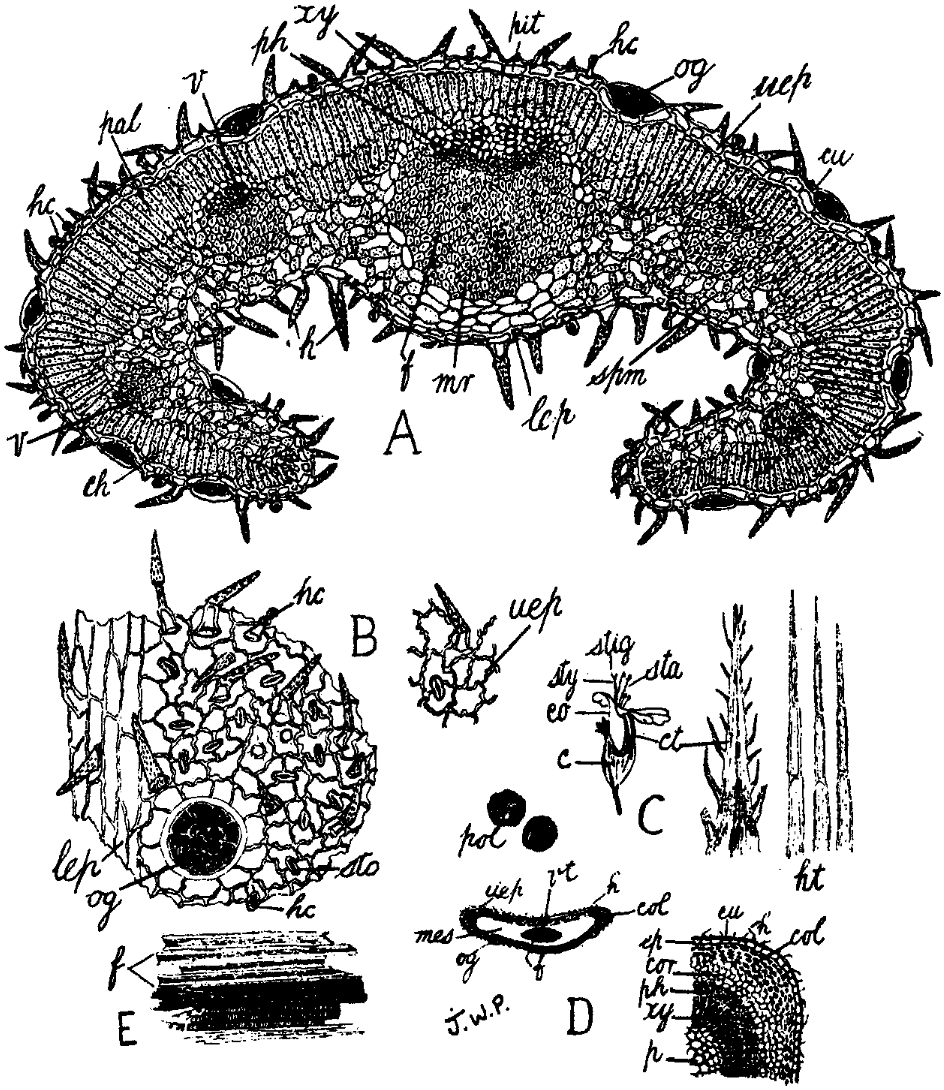

Fig. 34. THYME. (A) Cross section of leaf blade. (B) Surface view of lower epidermis (left); of upper epidermis (right). (C) Flower (left); calyx tooth and throat hairs (right). (D) Cross section of petiole (above); of corner of stem (right). (E) Fibrovascular tissue.

c, calyx; ch, chloroplasts; co, corolla; col, collenchyma; cor, cortex; ct, calyx tooth; cu, cuticle; ep, epidermis; f, fibers; h, hair; hc, capitate hair; ht, throat hairs; lep, lower epidermis; mes, mesophyll; mr, midrib; og, oil gland; pal, palisade cells; ph, phloem; p, pith; pit, pitted; pol, pollen; spm, spongy mesophyll; sta, stamen; stig, stigma; sto, stoma; sty, style; uep, upper epidermis; v, vein; vt, vascular tissue; xy, xylem.

Miscellaneous Aromatic Leaves

XXXVII. LAUREL LEAVES

Laurus nobilis L.
Family: *Lauraceae*

[ALSO CALLED BAY LEAVES]

GENERAL

An evergreen tree. Leaves alternate, petiolate, firm; flowers yellow; fruit a berry.

MORPHOLOGY

The dried leaves are greenish-brown to light brown on the upper surface, lighter on the lower surface; Mediterranean leaves from about 2.5 to 7.5 cm in length, Guatemala leaves to about 12 cm. Leaves elliptical, acute to moderately acuminate at the apex, acute at the base, entire or undulating, stiff in texture, brittle, glabrous; upper surface smooth, lustrous; lower surface dull; net venation, pinnate; midrib prominent; petiole short.

Odor pleasant; fragrant and delicately aromatic when the dried leaves are crushed. Taste, aromatic and bitter.

HISTOLOGY

Leaf

Cross section. A moderately thick cuticle covers the epidermis. The cells of the upper epidermis are rectangular in shape or nearly so, with thick outer walls. The cells of the lower epidermis are similar to those of the upper but

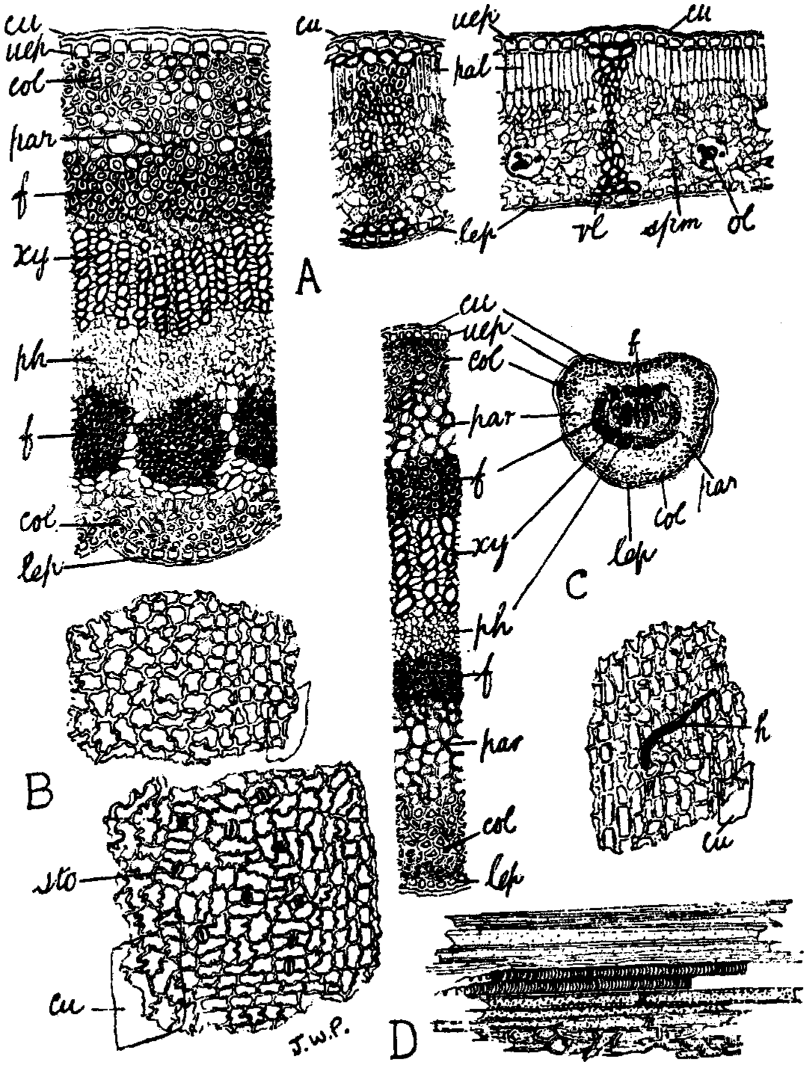

Fig. 35. LAUREL (BAY) LEAF. (A) Cross section through midrib (left); through vein (top, center); through portion of leaf blade (top, right). (B) Surface view of upper epidermis (above); of lower epidermis (below). (C) Cross section of petiole (above and left); surface view of epidermis of petiole (below). (D) Fibrovascular tissue.

col, collenchyma; cu, cuticle; f, fibers; h, hair; lep, lower epidermis; ol, oil; pal, palisade cells; par, parenchyma cells; ph, phloem; spm, spongy mesophyll; sto, stoma; uep, upper epidermis; vl, veinlet; xy, xylem.

the outer walls are thinner. The mesophyll consists of 2 layers of palisade cells, spongy tissue, oil cells, fibrovascular and collenchyma tissue. The palisade cells vary in size from about 33 to 44 microns, long axis. The oil cells occur in the spongy mesophyll. The fibrovascular bundle of the midrib is large, with the vessels arranged in radial rows. Numerous fibers accompany the phloem and xylem tissues. Collenchyma tissue occurs above and below the fibrovascular bundle of the midrib but does not accompany the vascular tissue of the veins.

In surface view, the cells of the upper epidermis are irregular to oblong-rectangular in shape, always the latter near and over the midrib and veins. The cell walls are sinuous, thick, and porous. The cells of the lower epidermis are similar in shape to those of the upper but larger and with thinner walls. There are no stomata on the upper surface. Stomata are numerous on the lower surface; the guard cells are surrounded by 4 epidermal cells.

Petiole

Cross section. A moderately thick cuticle covers the epidermis. The epidermal cells are rectangular in shape; the outer walls are thick. Occasional unicellular hairs are present. The mesophyll consists of parenchyma cells with moderately thick walls, and oil cells. The fibrovascular tissue occupies a central position in the mesophyll.

In surface view, the cells of the epidermis are irregular to oblong-rectangular in shape; the walls are thick. Occasional, curved, pointed, unicellular hairs up to about 220 microns in length and with blackish contents occur on the epidermis.

XXXVIII. PARSLEY

Petroselinum sativum Hoffm.
Family: *Umbelliferae*

GENERAL

This is a biennial, herbaceous plant with rich green leaves and small white flowers; fruit, a schizocarp.

MORPHOLOGY

Leaves pinnately compound, leaflets 3-lobed, each lobe divided into smaller, tooth-like lobes or segments; curly; green. The commercial product consists of the dried leaves, broken, shrivelled, curled.

Dried parsley leaves have a characteristic, agreeable, aromatic odor and taste.

HISTOLOGY

Leaflet

Cross section. A thin, striated cuticle covers the epidermis. The cells of the upper epidermis are nearly rectangular in shape, and vary in size up to about 44 microns, long axis, except over the main veins where they are larger and frequently ballooned. The cells of the lower epidermis are similar to those of the upper but less rectangular and not ballooned over the veins. The mesophyll consists of a layer of palisade cells, and spongy tissue. The palisade cells are around 40 to 55 microns, long axis, in the mature leaflet. Vascular bundles traverse the spongy mesophyll. Collenchyma tissue is present over and under the vascular bundles but is more abundant below, i.e., toward the lower epidermis. Adjacent to the phloem tissue there is a vitta or oil cavity, characteristic of the *Umbelliferae.*

In surface view, except over the veins the cells of the upper and lower epidermis are irregular in shape with wavy walls, and vary in size to about 70 microns, long axis, with the occasional elongated cell exceeding this length. Over the veins the upper epidermal cells are mostly ballooned; the lower epidermal cells are oblong-rectangular or elongated and tapered in shape, and vary in size to about 90 microns, long axis. Stomata are few in the upper epidermis, numerous in the lower; the guard cells are surrounded by 2, 3, or 4 epidermal cells.

Rachis

Cross section. The rachis, from which the leaflets arise, consists of (a) cuticle; (b) an upper and lower epidermis; (c) a large central fibrovascular bundle with thin-walled fibers. In longitudinal view the fibers are long with thin walls; the vessels are spiral; (d) outer and inner mesophyll tissue of small parenchyma cells with chloroplasts; (e) central mesophyll tissue of large, empty parenchyma cells; (f) oil cavities or canals; and (g) collenchyma tissue. The rachis is ribbed, and the collenchyma cells occur in groups at each rib; they give strength and rigidity to the rachis. The collenchyma is laid down thickly.

In surface view, between the ribs the cells of the epidermis are elongated, and the cell walls curve in a slightly wavy or sinuous way. Stomata are present and are surrounded by 2, 3, or 4 epidermal cells with the 3-cell arrangement predominant. Over the ribs and collenchyma tissue the epidermal cells are oblong-rectangular in shape or nearly so. They vary in size, with some reaching 200 microns, long axis. The cell walls are straight, beaded in places, and thicker than those of the cells between the ribs. All of the epidermal cells are striated and covered with a striated cuticle.

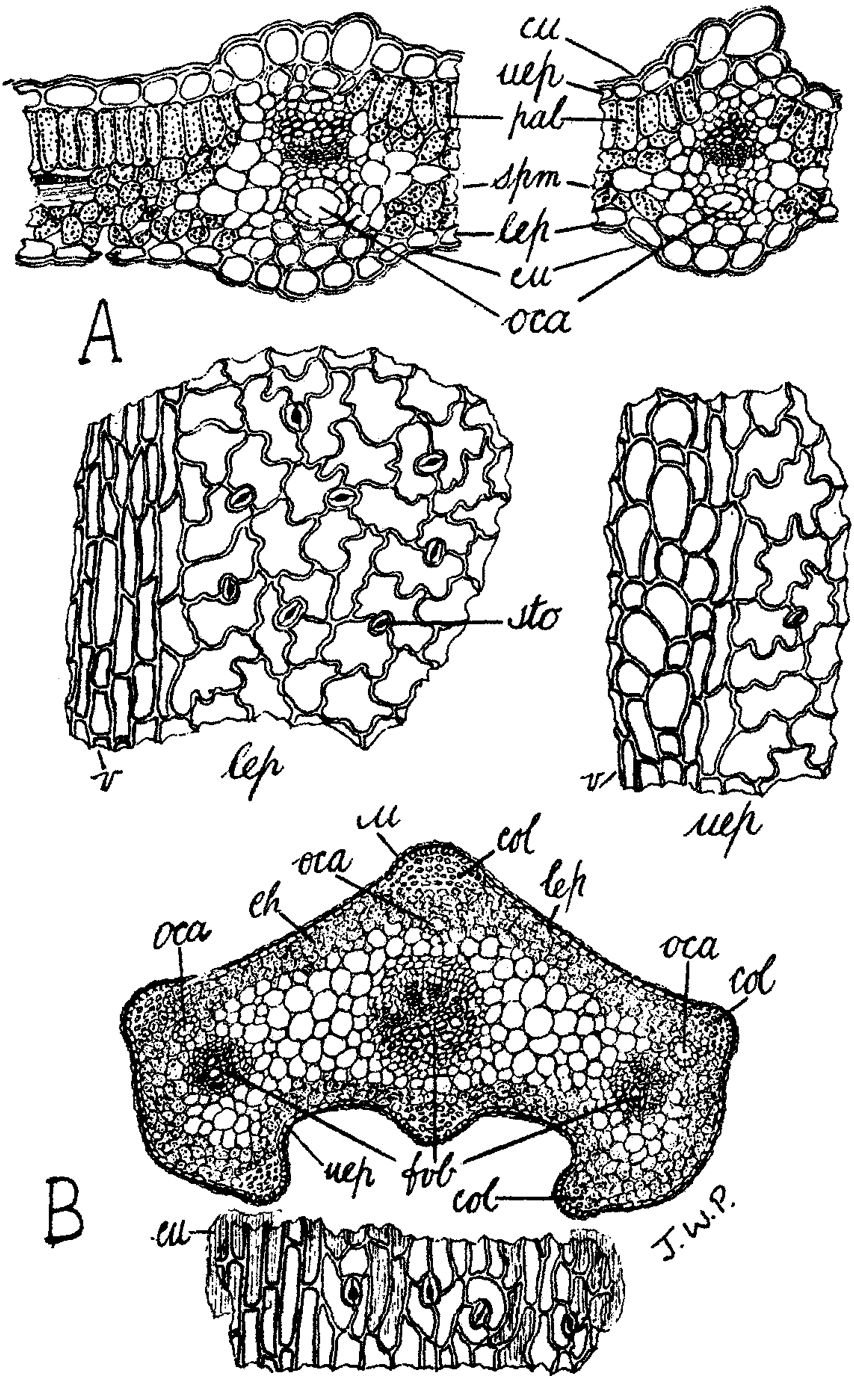

Fig. 36. PARSLEY. (A) Cross section through a large vein of leaflet (above, left); and through a small vein (above, right). Lower epidermis between veins, and over a vein, surface view (below, left); upper epidermis between veins, and over a vein, surface view (below, right). (B) Cross section of rachis (above); epidermis of rachis, surface view (below).

ch, chloroplast cells; col, collenchyma; cu, cuticle; fvb, fibrovascular bundle; lep, lower epidermis; oca, oil cavities; pal, palisade cells; spm, spongy mesophyll; sto, stoma; uep, upper epidermis; v, vein zone.

XXXIX. CHERVIL

Anthriscus cerefolium Hoffm.
Family: *Umbelliferae*

GENERAL

Chervil is an annual herb, propagated by seed. The seed is sown in the early spring and the plants are ready for harvesting in April or May. The plant ordinarily reaches a height of 45 to 60 cm, but as cultivated for commerce in the United States the plants range from 25 to 30 cm in height at maturity. Chervil has decompound leaves and small white flowers arranged in compound umbels of 3 to 5 slender rays. The lateral umbels are sessile and the terminal umbels pedunculated. The involucre is composed of 1 to 3 bracts, the involucels of 2 to 3 bracts. The involucre is sometimes absent.

Chervil is cultivated for the spice trade in France and in the United States. In France the leaves are dehydrated by circulating air warmed to a temperature of 50° C. The leaves are fragmented by mechanical means and packed in plastic lined containers. The net weight of the package is 12½ kilograms (27½ lbs). The French product is exported to all parts of Europe. In the United States the leaves are similarly processed for the American spice trade. There are no flowering tops in the commercial product.

MORPHOLOGY

Leaves decompound with more or less oval, cut leaflets; leaves alternate, tender, thin, pale green; 2 to 4 cm long and 2 to 4 cm wide; net venation, pinnate; a few hairs on the midvein and margin of leaflets, visible only with the microscope. As cultivated for commerce in the United States the leaves are about 1.6 to 2.5 cm in length and 1.6 to 2 cm in width.

The odor and taste of dried chervil is faintly reminiscent of a blend of caraway and anise.

HISTOLOGY

Cross section of leaflet: A thin cuticle covers the upper and lower epidermis; it is striated at the margin and over the lower epidermis of the midvein. The cells of the upper and lower epidermis are transversely irregularly oblong-rectangular, or nearly so, and some cells of the midvein have a slight tendency to balloon, more so in the lower epidermis. The mesophyll consists of a single row of palisade cells in the upper part and a spongy mesophyll of parenchyma cells in the lower. The palisade cells vary in size from about 18 to 75 microns, long axis, and from about 16 to 35 microns, short axis. The cells of the spongy mesophyll vary in shape; many are elliptical, or nearly so, some have a tendency to transverse oblong-elongation, some are isodiametric, and others are irregular. The palisade and spongy mesophyll cells contain chloroplasts. The vascular system traverses the spongy mesophyll. Oil ducts or secretory canals, circular in shape, accompany the main veins and are situated adjacent to and below the phloem tissue of the vascular bundle.

In surface view, except over the margin and main veins, the cells of the upper and lower epidermis are irregular in shape, and they vary in size to about 110 microns, long axis. The cell walls are undulating, those of the lower epidermis being the more wavy. The epidermal cells of the main veins and margin, particularly those of the lower epidermis of the midvein, are longitudinally oblong, oblong-pointed, or irregularly angled, with nearly straight or slightly curved walls. The walls of the epidermal cells of the midvein are faintly beaded, more distinctly so toward the base of the leaflet. Stomata are numerous in the lower epidermis and almost absent in the upper, an examination of various areas of the upper epidermis of a number of leaflets showing no stomata or only 1, 2, or 3. In size the greater number of stomata are about 23 microns, long axis, and the guard cells are surrounded by 2, 3, 4 or 5 epidermal cells. Hairs arise from the epidermal cells of the main veins and the margin and occur on both the upper and lower epidermis but are more numerous on the lower; they are not abundant. The hairs on the upper epidermis are very few in number and occur for the most part on the margin. Except for a very occasional bicellular type the hairs are unicellular, clear, and pointed. In size they vary in length to about 550 microns and are about 45 microns broad at the base. Short, sharp, tooth-like hairs emerge at irregular intervals from the edges of the lobes of the leaflet, and most lobes terminate in such an emergence.

Rachis

Cross section of rachis: A thin, striated cuticle covers the epidermis. The cells of the upper and lower epidermis are irregularly oblong-rectangular, or nearly so, and occasionally almost isodiametric in shape. They vary in size from about 10 to 23 microns, long axis, with outer walls from about 5 to 7 microns in thickness. The mesophyll consists of parenchyma cells with small intercellular spaces. A few collenchyma cells occur immediately within the epidermis over the ribs. There are three vascular bundles, the largest being centrally situated in the mesophyll; a small bundle is situated in the region of each upper corner. An oil duct accompanies each vascular bundle. The oil duct accompanying the large central bundle is situated adjacent to and below the phloem tissue. The ducts acompanying the upper bundles are situated adjacent to and at the outer side of the phloem tissue.

In surface view, the epidermal cells are for the most part longitudinally oblong-rectangular or oblong-pointed in shape with nearly straight or slightly curved walls.

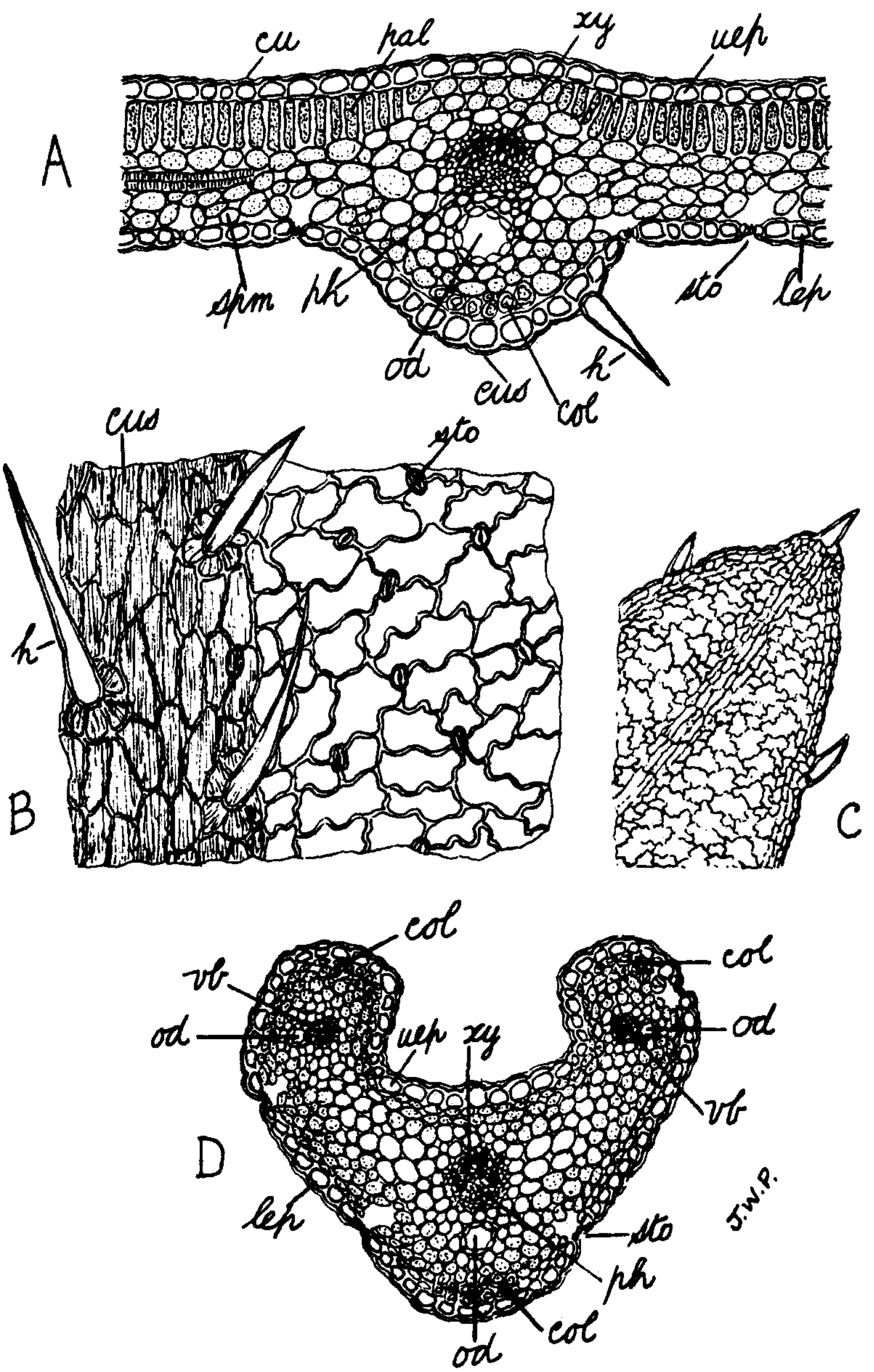

Fig. 37. CHERVIL. (A) Cross section of a main vein of a leaflet. (B) Lower epidermis, surface view. (C) Apex of a lobe of a leaflet. (D) Cross section of rachis.

col, collenchyma; cu, cuticle; cus, striated cuticle; h, hair; lep, lower epidermis; od, oil duct; pal, palisade cells; ph, phloem; spm, spongy mesophyll; sto, stoma; uep, upper epidermis; vb, vascular bundle (vein); xy, xylem.

XL. TARRAGON

Artemisia dracunulus L.
Family: *Compositae*

GENERAL

There are two varieties of tarragon known to commerce—namely, Russian tarragon and French tarragon. The former is reported to have coarser leaves than the latter, often called the true tarragon, and a less desirable flavor.

Tarragon produced in France enjoys wide distribution in Europe.

French tarragon reaches a height of about 70 cm and has small, very pale yellow, generally sterile flowers. Because of the latter, propagation is accomplished by root division or by cuttings. At maturity, the leaves are harvested, dried by circulated warm air and brought to the desired degree of fragmentation by mechanical grinding. The prepared dried herb is packaged in plastic bags and kraft paper for delivery in France and for export to other European countries. The package has a net weight of 12½ kilograms (27½ lbs).

It is the French tarragon variety that is cultivated in the United States for the North American spice trade. It is propagated as above, harvested at maturity, and dehydrated with controlled artificial heat and air to maintain both color and aroma. The dried leaves are mechanically fragmented with a series of machines which mill, brush, shake, blow and screen the leaf particles through specified apertures.

MORPHOLOGY

Leaves lanceolate, entire, sessile, and (with the exception of a few minute capitate hairs) glabrous; bright green; net venation, pinnate; midrib and margin ribs prominent. The edges of the dried leaves are curled toward the lower surface; finely revolute. In size, the whole dried leaves vary to about 4 cm in length, and in width to about 3.5 mm.

Odor and taste: Agreeable, aromatic and reminiscent of anise.

HISTOLOGY

Leaf

Cross section of the leaf: A thin cuticle, striated over the midrib and marginal veins, covers the upper and lower epidermis. The cells of the upper and lower epidermis are transversely oblong-rectangular, or nearly so. They vary in size from about 18 to 50 microns, long axis, and from about 10 to 30 microns, short axis. The outer walls of the midrib epidermal cells are moderately thick, being about 10 microns on the upper side and 11 or 12 microns on the lower. An occasional, short capitate hair, or the remains of one, may be seen. Stomata are present in both the upper and lower epidermis.

The mesophyll consists of two rows of palisade cells in the upper part and one row in the lower, and a central spongy mesophyll of parenchyma cells with intercellular spaces. The palisade cells vary in size from about 36 to 90 microns, long axis, and from about 18 to 22 microns, short axis. The palisade and spongy mesophyll cells contain chloroplasts. The vascular tissues traverse the spongy mesophyll. As in most leaf cross sections, veins cut transversely are seen in some areas of the spongy mesophyll. Sometimes, 3 or 4 fibers accompany the phloem of the midrib.

A few collenchyma cells usually occur immediately within the lower epidermis of the midrib of mature leaves. Oil ducts or secretory canals, more or less circular in shape, occur adjacent to the vascular bundles. In some cross sections as many as 7 or 8 ducts are seen, in others 5 or 6. Usually, there are two ducts in the midrib area, one of which is situated above and to the left of the vascular bundle, the other above and to the right of the bundle; one duct situated between the two small vascular bundles of the leaf margin, and one duct accompanying each of the veins between the midrib and margin. However, in some sections there may be only one vascular bundle in the margin with an oil duct situated at the side or above the bundle. There is not an absolute uniformity or regularity of arrangement.

In surface view, except over the midrib and margin veins, the cells of both the upper and lower epidermis are irregular in shape and vary in size to about 113 microns, long axis. The cell walls are undulating, those of the lower epidermis being the more wavy. The epidermal cells of the midrib and margin veins are longitudinally oblong-rectangular, oblong pointed, or angular with nearly straight, beaded walls. They vary in size to about 145 microns, long axis. Stomata are numerous in both upper and lower epidermis with the greater number being in the lower, about 25% more. They are about 36 microns, in size, long axis, and the guard cells are surrounded by 3, 4, and occasionally 5, epidermal cells. Occasional, small, inconspicuous capitate hairs emerge from the epidermis. They are short and about 35 to 40 microns in diameter. Very few perfect specimens of these hairs remain on the dried leaves of the commercial product.

Stem

Cross section of stem: A thin, striated cuticle covers the epidermis. Two rows of collenchyma cells underlie the epidermis and these increase in number to five or six rows in the corners of the stem. The remaining cortex cells are parenchymatous with intercellular spaces. These cells vary in size to about 36 microns, long axis. The cortex cells contain chloroplasts. An endodermis consisting of an unbroken sheath of cells envelops the vascular system and pith. In prepared sections, these cells show no contents. They are tangentially oblong, or nearly so, in shape, and vary in size from about 22 to 46 microns, long axis. Oil ducts or secretory canals occur in the concave areas of the parenchymatous cortex between the ribs and adjacent to the endodermis. They are more or less elliptical in shape, and vary in size from about 45 to 68 microns, long axis. Fibrovascular bundles grouped closely together encircle the pith. The pith consists of parenchyma cells with pitted walls. These cells vary in size to about 68 or 70 microns, long axis, and occasionally larger.

In surface view, the cells of the epidermis are longitudinally oblong, oblong-pointed, angular, or irregularly angled with nearly straight or curved, beaded walls. Stomata are present.

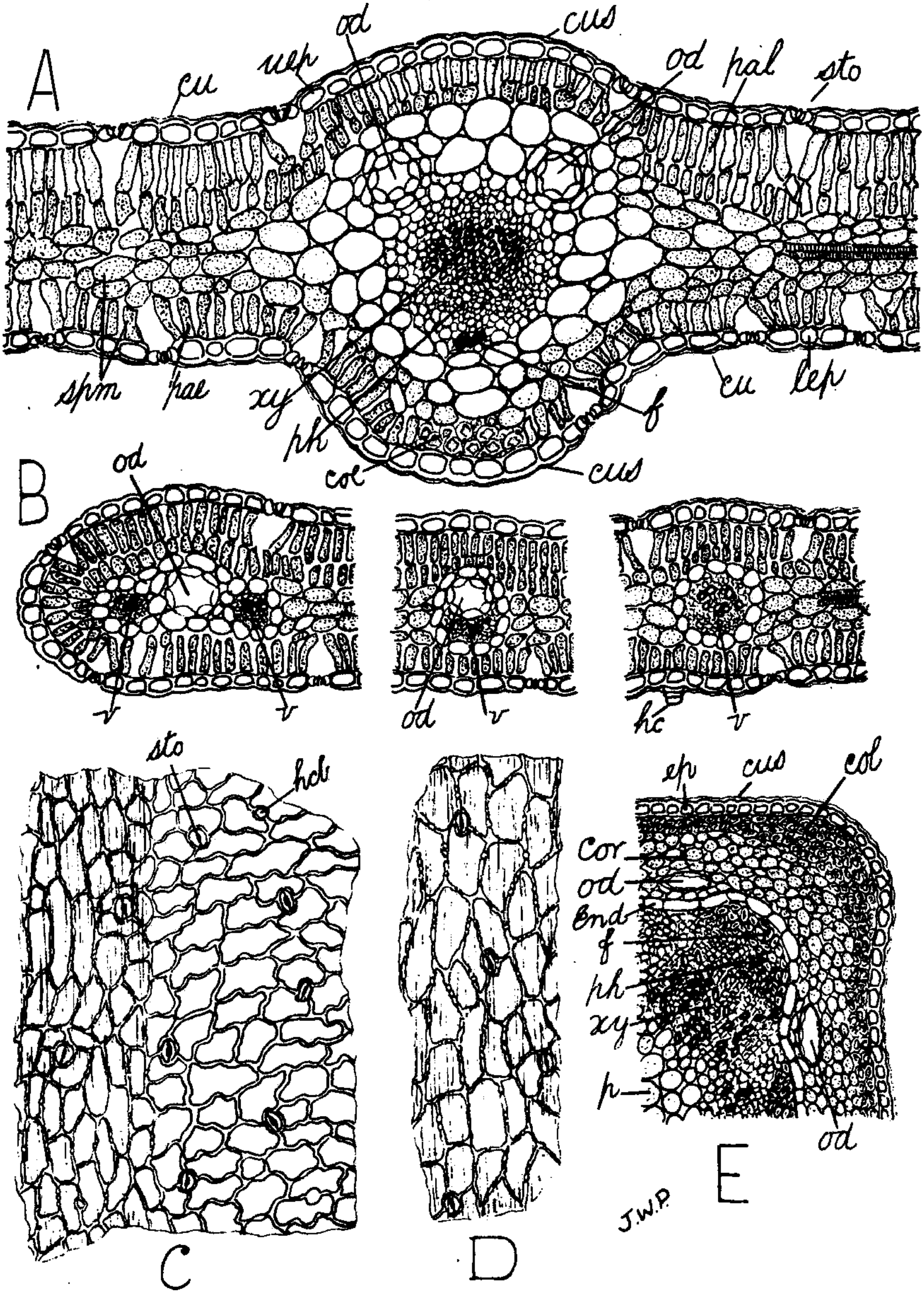

Fig. 38. TARRAGON (A) Cross section through midrib. (B) Cross section of leaf margin (left); portion of leaf blade through a vein with oil duct (center); and of a vein with no oil duct (right). (C) Upper epidermis, surface view. (D) Epidermis of stem, surface view. (E) Cross section of a portion of stem.

col, collenchyma; cor, cortex; cu, cuticle; cus, striated cuticle; end, endodermis; ep, epidermis; f, fibers; hc, capitate hair; heb, capitate hair base; lep, lower epidermis; od, oil duct; p, pith; pal, palisade cells; ph, phloem; spm, spongy mesophyll; sto, stoma; uep, upper epidermis; v, vein; xy, xylem.

Bulbs

XLI. GARLIC

Allium sativum L.
Family: *Liliaceae*

GENERAL

This is a hardy, perennial, bulbous plant with long, flat, linear leaves, and purple flowers. The bulblets are also known as "cloves" of garlic.

MORPHOLOGY

Dried, subglobular, compound bulb consisting of several bulblets contained within whitish, membranous scales attached to a short, disk-like, woody stem with numerous rootlets on the underside. Bulblets irregularly ovoid, dorsal surface convex, each consisting of 2 or 3 yellowish-green leaves folded longitudinally and contained within 2 white, fleshy, modified leaf bases or scales surrounded by 2 thin, whitish scales, the outermost being very thin, papery, and brittle.

The spice is the ground product of dehydrated garlic, and sold as Garlic powder. In the finer grades only the selected cloves of garlic are used. The powder is creamy-white or cream, and free running.

Odor strongly alliaceous; taste intensely pungent.

HISTOLOGY

Bulblet

Outer Scale. Cross section. The outer scale consists of (a) an outer epidermis; (b) an hypodermal crystal layer underlying the outer epidermis; (c) several layers of mesophyll parenchyma cells; (d) vascular tissue; and (e) an inner epidermis.

In surface view, the cells of the outer epidermis are elongated, narrow, with thin, porous walls; those of the inner epidermis are elongated, narrow, with thin walls. The cells of the hypodermal crystal layer are ellipsoidal with thick, porous walls; each cell contains a large, prismatic crystal of calcium oxalate, and many cells have, in addition, some small, prismatic crystals of the same substance. The long axes of the large crystals tend to lie parallel, or nearly so, to the long axes of their cells; and the long axes of the cells lie rectangularly to the long axes of the overlying epidermal cells; this arrangement holds true in general. The vessels are spiral. The veins run parallel to each other.

Inner Scale. The inner scale consists of the same number and type of tissues as the outer scale with following differences: The cells of the outer epidermis are markedly sclerenchymatous; in surface view, they are elongated, with greatly thickened walls and very narrow lumen. The cells of the hypodermal crystal layer, in surface view, are somewhat smaller than those of the outer scale, the walls are more frequently pitted, and the crystals are slightly smaller.

Fleshy Leaf Bases. Two whitish, fleshy, modified leaf bases form the bulk of the bulblet and enclose the small foliage leaves. The thickness of the outer leaf base is considerably greater than that of the inner. Both consist of an outer and inner epidermis, mesophyll, and scattered vascular bundles.

In surface view, the cells of the outer epidermis are thin-walled, tend somewhat to the oblong-rectangular in shape, and are about 30 microns in width, and up to about 90 microns in length. The cells of the inner epidermis are thin-walled, less rectangular than those of the outer epidermis, and are about 55 microns in width, and up to about 275 microns in length. The mesophyll consists of large, thin-walled parenchyma cells, mostly polygonal in shape, with small intercellular spaces. The vessels are spiral.

Foliage Leaves. There are usually 3 of these leaves developed. The upper and greater part of the leaf is greenish-yellow, the lower part is whitish. In cross section, the greenish-yellow portion of the leaf is complete with epidermal tissue including stomata; a mesophyll of isodiametric, chloroplast-containing cells underlying the outer and inner epidermis, with a central zone of polygonal cells without chloroplasts. Vascular tissue traverses the mesophyll.

Stem

The stem is the small, disk-like base of the bulblet. It emerges from the hard, woody stem of the compound bulb from which the thin, papery scales enveloping the bulblets arise, and on which the developed rootlets are seen. It consists of parenchyma cells, scattered vascular tissue, and the rudiments of adventitious roots.

If the woody, rootlet-bearing stem of the compound bulb is not removed and discarded in the preparation of garlic powder, the product will contain, in addition to the tissues described above, stone cells, sclerenchymatous pitted cells, many of the latter containing prismatic crystals of calcium oxalate, and spiral and reticulate vessels of the xylem tissue; all present in that part of the plant.

The developed rootlet consists of epidermis, exodermis, cortex, endodermis, pericycle, phloem and xylem tissues.

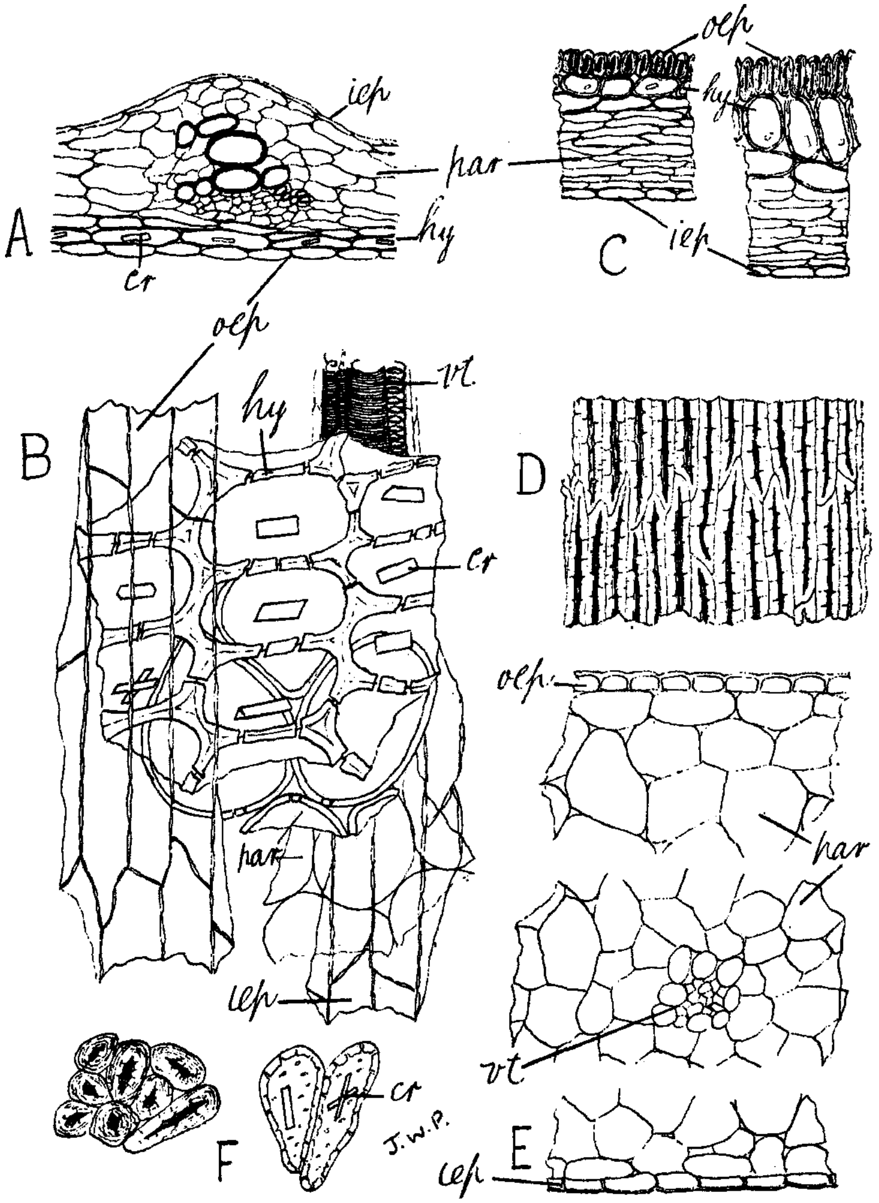

Fig. 39. GARLIC. (A) Outer leaf scale, cross section through vascular bundle. (B) Outer leaf scale, surface view of outer epidermis, hypodermal crystal layer, parenchyma, vascular tissue, and inner epidermis. (C) Cross section of a portion of inner leaf scale. (D) Surface view of sclerenchymatous outer epidermis of inner leaf scale. (E) Cross section of fleshy leaf base. (F) Stone cells, and sclerenchymatous pitted cells with crystals, from woody stem of compound bulb.

cr, crystal; hy, hypodermal layer; iep, inner epidermis; oep, outer epidermis; par, parenchyma; vt, vascular tissue.

XLII. ONION

Allium cepa L.
Family: *Liliaceae*

GENERAL

This is a biennial, bulbous plant with long, slender, dark green tubular leaves; flowers small, white or greenish-white, borne in a globular head on a tubular stalk.

MORPHOLOGY

A tunicate bulb consisting of several white, fleshy, modified leaf bases or scales surrounded by pigmented membranous scales. Stem small, disk-like, and bearing numerous rootlets on the underside.

The spice is the ground product of dehydrated onions, and sold as onion powder. It is creamy-white in color and free running.

Odor alliaceous; taste pungent, sharp.

HISTOLOGY

Membranous Leaf Scales

Cross section. This consists of (a) an outer epidermis; (b) a hypodermal crystal layer underlying the outer epidermis; (c) several layers of collapsed mesophyll parenchyma cells; (d) vascular tissue; and (e) an inner epidermis.

In surface view, the epidermal cells are elongated and narrow. The walls of the epidermal cells are thin; those of the outer epidermis are slightly thicker than those of the inner. The cells of the hypodermal crystal layer are large and regularly arranged; the walls are thicker than those of the overlying epidermal cells. Each cell contains one large, prismatic crystal of calcium oxal-

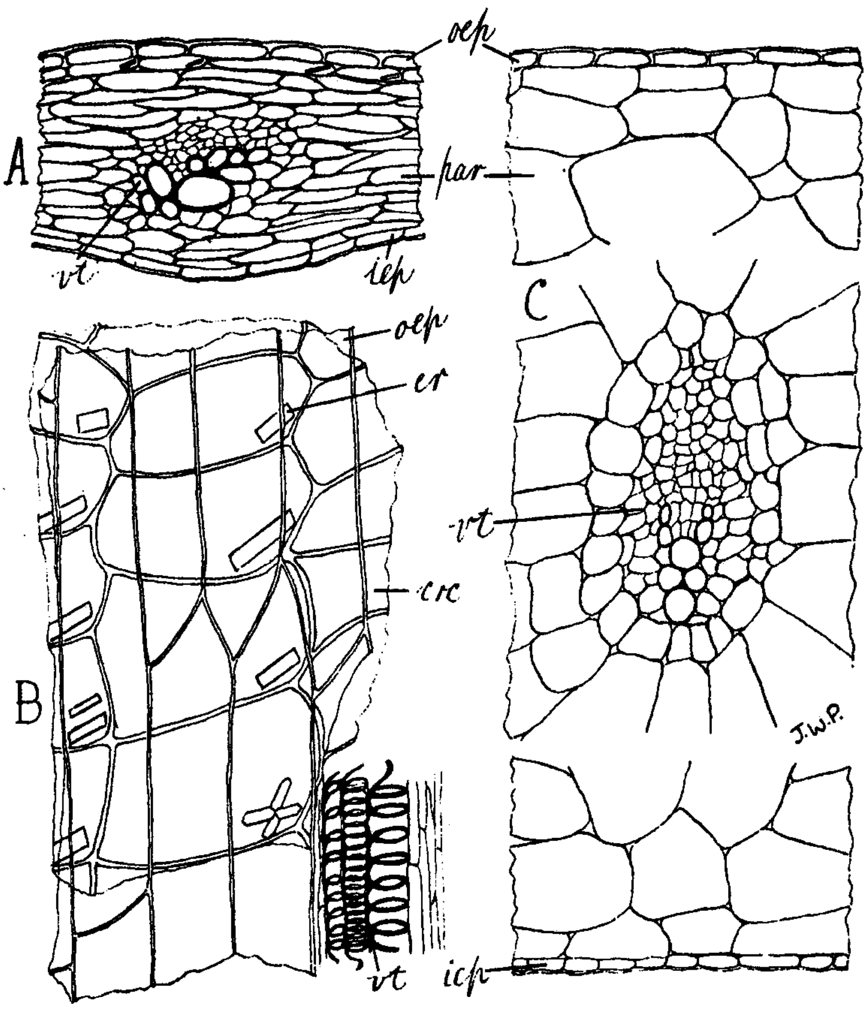

Fig. 40. ONION. (A) Leaf scale, cross section through vascular bundle. (B) Leaf scale, surface view of outer epidermis, crystal layer, and vascular tissue. (C) Fleshy leaf base, cross section through a vascular bundle.

cr, crystal; crc, crystal cells; iep, inner epidermis; oep, outer epidermis; par, parenchyma tissue; vt, vascular tissue.

ate, and some cells have, in addition, one or more small, prismatic crystals of the same substance. The crystals usually occur in similar corners of the cells in which they are contained, with their long axes tending to lie diagonally to the long axes of the overlying epidermal cells. The long axes of the crystal cells lie rectangularly to the long axes of the epidermal cells. Vascular tissue traverses the mesophyll; the vessels are spiral.

Fleshy Leaf Bases

The whitish, modified leaf bases form the bulk of the bulb, and consist of thin-walled epidermal cells, elongated in surface view; thin-walled mesophyll parenchyma cells; and vascular tissue with spiral vessels.

Stem

The shallow, disk-like stem situated at the base of the bulb consists of parenchyma cells, vascular tissue, and the rudiments of adventitious roots. Spiral and reticulate vessels occur in the vascular tissue.

Part 2

CHEMICAL COMPOSITION

INTRODUCTION

Spices are dried plant products which add flavor, relish, or piquancy to foods. They consist of rhizomes, barks, leaves, fruits, seeds, and other parts of plants. Most are fragrant, aromatic, and pungent.

The bulk of the dry matter of these products consists of carbohydrates—organic compounds of carbon, hydrogen and oxygen, the hydrogen and oxygen usually in the same proportion as in water. Cellulose, starch, sugars, pentosans, mucilage are carbohydrates.

Cellulose is a carbohydrate used by the plant in the building of cell walls. Parenchyma and collenchyma tissues are cellulose, sclerenchyma tissue is a combination of cellulose and lignin, lignocellulose. The nature of lignin is not fully known. Cellulose is a complex organic compound, a polysaccharide composed of a long chain of monosaccharides, insoluble in water and in most solvents, hydrolyzed by sulfuric acid into a colloidal substance which gives a blue reaction with iodine, dissolved by a concentrated solution of zinc chloride, and by cuprammonia solution. It is tasteless.

Starch is a polysaccharide with the same basic formula as cellulose but less complex. Its starting point is glucose and it originates in leucoplasts (colorless plastids), the starch being laid down in layers around a central core or point of origin called the hilum. The granules have a characteristic size and shape depending upon the species of the plant, and, because of this, starch serves as a criterion for the detection of adulteration. Starch occurs in many of the spices, being abundant in ginger, nutmeg and pepper. A transitional starch product called amylodextrin occurs in mace. Starch reacts with a blue color, and amylodextrin with a reddish-brown color, when treated with iodine-potassium iodide solution on the slide. When boiled with water, the starch granules swell forming a solution colloidal in nature which when cool reacts with a dark blue color on the addition of a few drops of iodine-potassium iodide solution. Nutmeg (starch content) reacts as above when boiled with water; mace (amylodextrin content) when boiled with water reacts with a pale pinkish-brown color on the addition of iodine-potassium solution on cooling down.

Of the sugars, glucose and fructose are the most commonly found. Glucose probably occurs in all plants. It is a monosaccharide, hexose, readily soluble in water, and with a sweet taste. It undoubtedly enters into numerous complex chemical processes within the plant. Cellulose and starch yield glucose on complete hydrolysis. Glucosides, consisting of glucose combined with one or more organic substances are of common occurrence in plants. The decomposition of a glucoside within the plant, effected by an enzyme, may yield a substance of characteristic odor or taste. For example, the pungency of black mustard seed is due to allyl isothiocyanate, produced with glucose and potassium hydrogen sulfate when the glucoside sinigrin is decomposed by the action of the enzyme myrosin.

Pentosans are widely distributed in plants, and occur in many spices. They are polysaccharides closely related to cellulose, and consist of araban and xylan. On hydrolysis they yield the pentoses arabinose and xylose. Xylan occurs in lignified cell walls, in seed coats, and probably in other zones of lignified tissue. It is probably associated with structural, supporting, and protective processes.

Mucilage is a carbohydate whose chemistry is imperfectly known; it yields pentoses and hexoses when broken down. Layers of mucilage constitute a part of certain cell walls, hard and horny in the dry condition, but which form a thick, viscid, adhesive liquid when soaked in water. Mucilage occurs in mustard seeds, fenugreek, and some other spices.

Fixed oil constitutes a large part of some spice products, poppy and sesame seed, for example. It is present in endosperm and embryo tissue in a number of others. Like carbohydrates, the fixed oils contain carbon, hydrogen and oxygen, but have relatively less oxygen and more hydrogen. They are lighter than water, and leave a permanent, translucent stain on paper. Fixed oils dissolve readily in ether and chloroform. In general, they have no particular odor or taste. Fixed oils are compounds of glycerine with various fatty acids; esters of the trihydric alcohol, glycerol. Except those of mustard, poppy and sesame seeds, the fixed oils of the spices have no commercial value.

Proteins are complex organic compounds made up of simpler compounds known as amino acids. They consist of carbon, hydrogen, oxygen, and nitrogen; many contain sulfur, some contain phosphorous. In the storage organs of plants proteins commonly exist as aleurone grains; they are common in seeds and occur in all of the seeds of the Umbelliferae covered in this work, in fenugreek, mustard, poppy and sesame seeds, and in the seed of star anise; a protein substance occurs in the endosperm, and aleurone grains in the embryo, of cardamom seed.

Tannins are amorphous, colloidal, astringent substances. Their chemical constitution is not fully known. They combine with gelatine to form insoluble compounds; with ferric chloride solution they give a blue or green color. Tannins occur in many spices.

Resins are amorphous, solid or semisolid, complex substances. Associated with volatile oils they are known as oleoresins. Resins are insoluble in water, soluble in alcohol, ether, chloroform, and fixed oils. Resin occurs in many spices. The pungent principles of ginger and pepper are contained in their oleoresins.

Pigments are chemical compounds imparting color to the plant. The green color is caused by chlorophyll contained in chloroplasts within the plant cells. The reds, blues and purples are due to the presence of chemical compounds called anthocyanins. Yellow pigments, the carotinoids, are associated with chlorophyll in the chloroplasts, and also occur in chromoplasts. Pigments occur in most spices. The coloring matter of capsicum, turmeric, saffron and safflower are products of diverse and complex chemical compounds.

Calcium oxalate is widespread in plant organisms and occurs in many spice products. Prismatic crystals, large and small, and rosette crystals of calcium oxalate are very common. Very minute crystals deposited in powder-like form are known as crystal sand. The prismatic forms consist largely of needle-like, cubical, monoclinic, or tetragonal crystals, some very small, others very large.

Mineral elements. A formidable list of mineral elements occur in plants, but only a few are common, namely, potassium, sodium, calcium, magnesium, iron, phosphorous, sulfur, silicon, manganese, and chlorine. Mineral elements occur in all spices and may be determined by analysis of the ash.
The ash is obtained by incinerating the spice.

The volatile or essential oils are important products of spices. They contain terpenes, sesquiterpenes, alcohols, esters, aldehydes, ketones, phenols, ethers, etc., and in some oils sulfur and nitrogen. Most volatile oils are slightly soluble in water, imparting to the water their odor and taste. They are miscible with absolute alcohol, soluble in various dilutions of alcohol depending upon the kind of oil, and soluble in ether and in chloroform. They evaporate cleanly from paper. The volatile oils occur in secretory cells, vittae, glands, and other special tissues, and are responsible for the aroma and taste of most spices. The grinding of spices breaks down or exposes these tissues with the inevitable loss of aromatic principles by evaporation of the volatile oil. For this reason ground spices should be freshly prepared, kept well covered, and if for retail sale packed into containers promptly.

The chemistry of the volatile oils has been a subject of study for many years, and such knowledge as we have of the chemical compounds contained in the volatile oils of the spices comes to us from the work of a large number of able investigators.

Following the text of Part 3 a short bibliography is given. To those who seek further information than this brief work presents on the chemical composition of the spices these books are recommended.

XLIII. THE SPICES

Allspice

Allspice contains up to about 4.5% of volatile oil, a fixed oil, tannin, resin, proteins, cellulose, pentosans, starch, pigments, mineral elements, etc.

United States Government Standards require that allspice shall contain "not less than 8% of quercitannic acid (calculated from the total oxygen absorbed by the aqueous extract) not more than 25% of crude fiber, not more than 6% of total ash, nor more than 0.4% of ash insoluble in hydrochloric acid."

Canadian Government Standard,* B.07.006: "ALLSPICE or PIMENTO, whole or ground, shall be the dried, nearly ripe fruit of the pimento tree, shall contain not less than 8% quercitannic acid, calculated from the total oxygen absorbed by the aqueous extract, and shall contain not more than

(a) 25% crude fiber.
(b) 6% total ash.
(c) 0.4% ash insoluble in hydrochloric acid."

The essential oil, known as Oil of Pimenta, is a colorless, yellow, or reddish-yellow liquid with the odor and taste of allspice; it becomes darker with age. Oil of Pimenta is very slightly soluble in water, soluble in glacial acetic acid, soluble in 1 volume of 90% alcohol, and soluble in 2 volumes of 70% alcohol. The chief constituent of the oil is eugenol, empirical formula $C_{10}H_{12}O_2$; structural formula $CH_2{:}CHCH_2C_6H_5(OCH_3)OH$; a liquid with an odor of cloves, and a pungent taste. Eugenol constitutes from about 60 to 75% of the volatile oil of allspice. Other organic reported compounds present in the oil include eugenol methyl ether, empirical formula $C_{11}H_{14}O_2$; cineole, $C_{10}H_{18}O$; *l*-*α*-phellandrene, $C_{10}H_{16}$; and caryophyllene, $C_{15}H_{24}$.

The quantity of volatile oil and other ether-soluble constituents present in allspice depends upon the quality and age of the product. Using the continuous extraction method the author determined the ether extract in three samples of allspice as follows:

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*Division 7, Food and Drug Regulations, Food and Drug Directorate, Department of National Health and Welfare, Ottawa, Canada [3-9-1964].

Extract	*Sample (a)* %	*Sample (b)* %	*Sample (c)* %
Volatile ether	2.33	3.84	4.03
Fixed ether	4.27	5.10	5.49
Total ether	6.60	8.94	9.52

Sample (a) was a poor quality allspice, long in storage; sample (b) was a fair quality product; sample (c) was a good quality allspice recently imported. The total ash of sample (c) was 4.45%.

Anise

Anise fruit contains a volatile oil, fixed oil, protein, cellulose, sugar, pentosans, pigment, calcium oxalate, mineral elements, etc.

United States Government Standards require that the dried fruit of anise shall contain not more than 9% of total ash, nor more than 1.5% of ash insoluble in hydrochloric acid."

The important constituent of anise is its volatile oil, present in an amount of from about 1.5 to 3.5%. It is a colorless or pale yellow liquid, slightly soluble in water, soluble in about 3 volumes of 90% alcohol, soluble in chloroform, and in ether.

The principal constituent of the volatile oil of anise is anethole, empirical formula, $C_{10}H_{12}O$, structural formula, $CH_3CH{:}CHC_6H_4OCH_3$, present in the amount of from 80 to 90%. Anethole crystallizes from oil of anise on cooling. In the pure state, above 23°C, anethole is a colorless, highly refractive liquid possessing the aromatic odor and sweet taste of anise.

Other organic compounds reported present in the volatile oil of anise include methyl chavicol, empirical formula, $C_{10}H_{12}O$; anisketone, $C_{10}H_{12}O_2$; and anisaldehyde, $C_8H_8O_2$.

S.R. El-Deeb, M.S. Karawya, S.K. Wahba, and F.M. Ebeid (Fac. Pharm., Univ. Cairo) report that by gas-liquid partition chromatography oil of anise has the peaks of anethole and anisaldehyde.*

The fixed oil content of anise is about 10%.

Bay Leaves

See *Laurel Leaves.*

Basil

See *Sweet Basil.*

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*J. Pharm. Sci. (U. Arab. Rep.)3(1), 63-79 (1962); *CA.* 61, 8. 9351a

Capsicum

Capsicum fruits contain a fixed oil, resin, coloring matter, a pungent principle, protein, cellulose, pentosans, mineral elements, etc.

United States Government Standards cover paprika and cayenne pepper, the spice products of the capsicum fruits with which we are concerned, as follows: "Paprika. The dried, ripe fruit of *Capsicum annuum* L. It contains not more than 8.5% of total ash, not more than 1% of ash insoluble in hydrochloric acid. The iodine number of its extracted oils is not less than 125 nor more than 136.

"Hungarian Paprika. Paprika having the pungency and flavor characteristic of that grown in Hungary.

(a) Rosenpaprika, rosapaprika, rose paprika, is Hungarian paprika prepared by grinding specially selected pods of paprika, from which the placentae, stalks, and stems have been removed. It contains no more seeds than the normal pods, not more than 18% of nonvolatile ether extract, not more than 23% of crude fiber, not more than 6% of total ash, nor more than 0.4% of ash insoluble in hydrochloric acid.

(b) Koenigspaprika, king's paprika, is Hungarian paprika prepared by grinding whole pods of paprika without selection, and includes the seeds and stems naturally occurring with the pod. It contains not more than 18% of nonvolatile ether extract, not more than 23% of crude fiber, not more than 6.5% of total ash, nor more than 0.5% of ash insoluble in hydrochloric acid.

"Pimenton, Pimiento, Spanish Paprika. Paprika having the characteristics of that grown in Spain." It contains not more than 18% of nonvolatile ether extract, not more than 21% of crude fiber, not more than 8.5% of total ash, nor more than 1 per cent of ash insoluble in hydrochloric acid.

"Cayenne Pepper, Cayenne. The dried, ripe fruit of *Capsicum frutescens* L., *C. baccatum* L., or some other small-fruited species of capsicum. It contains not less than 15% of nonvolatile ether extract, not more than 1.5% of starch, not more than 28% of crude fiber, not more than 8% of total ash, nor more than 1.25% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.014: "CAYENNE PEPPER or CAYENNE, whole or ground, shall be the dried, ripe fruit of *Capsicum frutescens* L., *Capsicum baccatum* L., or other small-fruited species of Capsicum, and shall contain not more than

(a) 1.5% starch.
(b) 28% crude fiber.
(c) 8% total ash.

(d) 1.25% ash insoluble in hydrochloric acid, and shall contain not less than 15% non-volatile ether extract."

B.07.015: "PAPRIKA, whole or ground, shall be the dried, ripe fruit of *Capsicum annuum* L., and shall contain not more than

(a) 18% non-volatile ether extract.
(b) 23% crude fiber.
(c) 8.5% total ash.
(d) 1% ash insoluble in hydrochloric acid."

The National Formulary Standard states: "Capsicum is the dried ripe fruit of *Capsicum frutescens* Linn., known in commerce as African chillies, or *Capsicum annuum* Linne var. conoides Irish, known in commerce as Louisiana Long Pepper, or, of a hybrid between the Honka variety of Japanese Capsicum and the old Louisiana Sport Capsicum, known in commerce as Louisiana Sport Pepper (Family *Solanaceae*). Capsicum must be labeled to indicate which of the above varieties is contained in the package. Capsicum contains not more than 3% of its stems and calyxes, and not more than 1% of other foreign organic matter. It yields not less than 12% of non-volatile ether-soluble extractive and not more than 1.25% of acid-insoluble ash."

The principal coloring matter of capsicum fruits is the carotenoid pigment capsanthin, $C_{40}H_{58}O_3$. Other pigments present are carotene, capsorubin, zeaxanthin, cryptoxanthin, and lutein.

The pungent principle of capsicum is capsaicin, or capsaicine, $C_{18}H_{27}O_3N$. In the pure state, capsaicin consists of white crystals possessing a burning taste and very acrid vapors; insoluble in water, but freely soluble in ether, alcohol, and alkalies.

The oleoresin of capsicum, obtained by ether, alcohol, or acetone extraction, consists of a thick liquid, dark reddish-brown in color, with an intensely pungent taste. The chief active principle is capsaicin.

The quantity of capsaicin present in capsicum fruits varies, being greatest in the hot peppers, and slight or almost nil in the mild or sweet fruits.

Capsicum peppers contain appreciable quantities of Provitamin A, and Vitamins C, P, and J.*

Caraway

Caraway fruit contains a volatile oil, fixed oil, protein, cellulose, pentosans, calcium oxalate, mineral elements, etc. **United States Government Standards** require that the dried fruit of caraway shall contain "not more than 8% of total ash, nor more than 1.5% of ash insoluble in hydrochloric acid."

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*Instituto Nacional de Investigaciones Agronomicas Ministerio De Agricultura, Murcia, Spain. UNE 34029

Vitamin J—"A postulated antipneumonia principle which was also designated C_2." *Vitamins and Coenzymes*, Arthur Wagner and Karl Folkers, Copenhagen, 1964 John Wiley and Sons Inc., N.Y.

Canadian Government Standard, B.07.019: "CARAWAY SEED shall be the dried fruit of the caraway plant, and shall contain not more than

(a) 8% total ash.
(b) 1.5% ash insoluble in hydrochloric acid."

The principal constituent of caraway fruit is its volatile oil, of which it contains from about 3 to 7.5%. The chief constituents of the volatile oil of caraway are a ketone, d-carvone, empirical formula, $C_{10}H_{14}O$, and a terpene, d-limonene, $C_{10}H_{16}$. Many other organic compounds are reported present in the oil including dihydrocarvone, dihydrocarveol, carveol, acetaldehyde, methyl alcohol, furfural, diacetyl, etc. Carvone is present in the oil in the amount of from about 50 to 60%. In the pure state, carvone is a colorless liquid, very slightly soluble in water, soluble in alcohol, and in ether; it is primarily responsible for the caraway flavor. Limonene adds a lemon-like note to the oil; in the pure state it is a colorless liquid, insoluble in water, soluble in alcohol, and in ether.

S. R. El-Deeb, M. S. Karawya, S. K. Wahba, and F. M. Ebeid (Fac. Pharm., Univ. Cairo) report that by gas-liquid partition chromatography oil of caraway had peaks methyl salicylate, limonene, carvone, eugenol, α-pinene, and eucalyptol.*

The fixed oil content of caraway is about 15%. The fatty acids consist largely of oleic, linoleic, and petroselinic acids, with a small amount of palmitic acid. The discoverers of petroselinic acid showed it to be a higher-melting isomer of oleic acid.†

Cardamom

Cardamom seed contains a volatile oil, fixed oil, protein, cellulose, pentosans, sugar, starch, silica, calcium oxalate, mineral elements, etc.

United States Government Standards require that the dried seed of cardamom shall contain "not more than 8% of total ash, nor more than 3% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.020: "CARDAMOM SEED shall be the dried seed of cardamom, and shall contain not more than

(a) 10% total ash.
(b) 3% ash insoluble in hydrochloric acid."

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*J. Pharm. Sci. (U. Arab Rep.) 3(1), 63-79 (1962); *CA.* 61,8. 9351a

†Eckey, E. W., *Vegetable Fats and Oils*, p. 707, Reinhold Publishing Corp., New York, 1954.

Cardamom contains from about 2 to 10% of volatile oil, colorless or pale yellow, with an agreeable, aromatic, somewhat camphoraceous odor, and a pungent, aromatic taste.

M. C. Nigam, Ishwar C. Nigam, K. L. Handa, and Leo Levi (Food and Drug Directorate, Ottawa, Canada) report that an examination of the essential oil of cardamom by the gas-chromatographic analysis of fractions obtained by distillation under reduced pressure and by column chromatography showed 1.9% *a*-pinene, 4.5% sabinene, 0.2% myrcene, 14.3% limonene, 30.7% cineole, 1.9% *p*-cymene, 0.8% methyl heptenone, 0.9% linalool, 1.2% linalyl acetate, 0.8% *β*-terpineol, 3.7% 2-terpineol, 28.1% *a*-terpinyl acetate, 0.1% borneol, 0.3% neryl acetate, 0.7% geraniol, 1.4% nerol, 0.3% neolidol, 0.5% heptacosane, and 7.7% unidentified compounds.*

The following approximate composition of Mysore, Malabar, and Ceylon cardamom oils is reported by Y. S. Lewis, E. Sankaran Nambudiri, and T. Philip (Central Food Technol. Res. Inst., Mysore, India)

Constituent	*Mysore*	*Malabar*	*Ceylon*
α-Pinene	1.4	0.7	0.7
Sabinene	3.2	4.6	3.8
Myrcene	0.2	0.2	0.1
Limonene	2.4	1.7	2.2
Cineole	41.0	26.5	36.0
p-Cymene	0.5	0.7	0.4
Methylheptanone	1.2	1.5	0.8
Linaloöl	0.4	3.7	3.5
Linalyl acetate	1.6	7.7	2.6
β-Terpineol	0.8	0.7	2.1
α-Terpineol	0.8	1.0	1.0
α-Terpinyl acetate	30.00	34.5	30.0
Neryl acetate (+borneol?)	1.1	1.2	0.8
Geraniol	0.7	0.7	0.7
Nerol	1.4	0.6	1.6
Nerolidol	0.3	0.7	0.3
Solid (heptacosane?)	0.5	0.4	0.5
Unidentified compounds	12.5	12.9	12.9

The yield of oil by steam distillation was Mysore 9.1%, Malabar 10.0%, Ceylon 9.5%.**

An interesting report on the yield of volatile oil in cardamom seed when exposed to air for various lengths of time is that of Ogzewalla and Marlene Willms (Southwestern State College, Weatherford, Okla. U.S.A.). They report that the yield of oil from freshly gathered whole cardamom fruit was 4.8%; exposed to air 1 month, 2.9%; exposed to air 6 weeks, about 2.4%;

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* J. Pharm. Sci. 54(5), 799-801 (1965); *CA*. 63.2. 1651d.

** *Perfum. Essent. Oil Rec.* 57(10), 623-8 (1966) (Eng); *CA*. 66. 13993p.

exposed to air 14 months, 2.0%. Ground cardamom seed exposed to air 1 week, 2.4%; exposed to air 13 weeks, trace.*

Cassia

Cassia bark contains a volatile oil, fixed oil, resin, tannin, proteins, cellulose, pentosans, starch, calcium oxalate, mineral elements, etc.

United States Government Standards require that the powder made from cinnamon, in which they include the barks of Ceylon cinnamon, China cassia, and Saigon cassia, shall contain "not more than 5% of total ash, nor more than 2% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.007: "CINNAMON or CASSIA, whole or ground, shall be the dried bark of cultivated varieties of *Cinnamomum zeylanicum* Nees, or *C. cassia* L., from which the outer layers may have been removed, and shall contain not more than

(a) 5% ash.
(b) 2% ash insoluble in hydrochloric acid."

B.07.008: "CEYLON CINNAMON, whole or ground, shall be cinnamon obtained exclusively from *Cinnamomum zeylanicum* Nees."

The quantity of volatile oil and other ether-soluble organic compounds present in the spice depends upon the nature, quality, and condition of the bark. Employing the continuous extraction method, the author obtained the following results.

		Volatile Ether Extract %	*Fixed Ether Extract* %	*Total Ether Extract* %
Saigon Cassia,	sample (a)	4.72	3.85	8.57
	sample (b)	4.95	4.60	9.55
Batavia Cassia,	sample (a)	4.89	1.14	6.03
	sample (b)	4.50	1.15	5.65
Yunan Cassia,	sample (a)	2.87	2.47	5.34
	sample (b)	3.07	2.40	5.47
Kwangsi Cassia,	sample (a)	2.20	2.09	4.29
	sample (b)	2.21	1.89	4.10
China Cassia Chips		1.77	2.10	3.87

The total ash was determined by the author in five samples of cassia as follows:

		Total Ash %
Saigon Cassia,	sample (a)	4.29
	sample (b)	3.88
Batavia Cassia,	sample (b)	3.25
Yunan Cassia,	sample (a)	2.26
	sample (b)	2.20

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* *Proc. Okla. Acad. Sci.* 43, 57–60 (1962) (Pub 1963); *CA.* 60.7. 7867b.

The volatile oil of cassia contains from 80 to 95% of cinnamic aldehyde (described under Ceylon cinnamon). Other organic compounds reported present in the oil include cinnamyl acetate, and very small amounts of cinnamic acid, benzaldehyde, methyl salicylaldehyde, methyl *ortho*-coumaraldehyde, salicyaldehyde, salicylic acid, and courmarin.

Cassia Buds

Cassia buds contain a volatile oil, fixed oil, proteins, cellulose, pentosans, starch, calcium oxalate, mineral elements, etc.

The chief constituent of the volatile oil is cinnamic aldehyde, empirical formula C_9H_8O.

Celery

Celery fruit contains a volatile oil, fixed oil, resin, protein, cellulose, calcium oxalate, mineral elements, etc.

United States Government Standards require that the dried fruit of celery shall contain "not more than 10% of total ash, nor more than 2% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.021: "CELERY SEED shall be the dried fruit of the celery plant, and shall contain not more than

(a) 10% total ash.
(b) 2% ash insoluble in hydrochloric acid."

B.07.029: "CELERY SALT shall be a combination of ground celery seed or ground dehydrated celery and salt and shall contain not more than 75% salt."

B.07.030: "CELERY PEPPER shall be a combination of ground celery seed or ground dehydrated celery and ground black pepper and shall contain not more than 70% ground black pepper."

The principal constituent of celery fruit is its volatile oil, of which it contains from about 2 to 3%. The chief constituents of the oil are a terpene, *d*-limonene, empirical formula $C_{10}H_{16}$, a substance with a lemon-like odor, present in the amount of 60%, and a sesquiterpene, selinene $C_{15}H_{24}$, present in the amount of from 10 to 20%. The characteristic odor of this spice is believed to be mainly due to two oxygenated compounds present in the oil—namely, sedanolide $C_{12}H_{18}O_2$, and sedanonic acid anhydride $C_{12}H_{16}O_2$.

The fixed oil content of celery fruit is about 16%. The fatty acids consist largely of petroselinic, oleic, and palmitic acids.

Chervil

Chervil contains a volatile oil, cellulose, pigment, mineral elements, etc.

There does not appear to be any commercial production of the essential oil of chervil. It has probably been distilled in the laboratory and investigated but the literature seems to be silent concerning the chemical constituents of the oil.

Cinnamon, Ceylon

Ceylon cinnamon bark contains a volatile oil, fixed oil, tannin, resin, proteins, cellulose, pentosans, mucilage, starch, calcium oxalate, mineral elements, etc.

On distillation the bark yields from 0.5 to 1% of volatile oil. The chief constituent of the volatile oil of cinnamon bark is cinnamic aldehyde, empirical formula C_9H_8O, structural formula $C_6H_5CH{:}CH.CHO$, an aromatic, pungent, sweet-tasting, yellowish, oily liquid. Other organic compounds reported present in the oil include eugenol (4 to 8% or more), caryophyllene, *l*-phellandrene, *p*-cymene, *l*-*α*-pinene, *l*-linaloöl, furfural, methyl-*n*-amyl ketone, nonyl aldehyde, benzaldehyde, hydrocinnamic aldehyde, and cumaldehyde, all of which contribute to the very pleasing aroma and taste of Ceylon cinnamon.

Concerning the distillation and export of the volatile oil of cinnamon, the following is reported in Leaflet No. 51, Department of Agriculture, Ceylon, by F.A. Stockdale and J.C. Drieberg: "Cinnamon oil is distilled from the chips and trimmings of the quills; and this is known as 'bark oil.' " Before distillation the chips are macerated in sea water or a strong solution of brine for 2 to 3 days. The yield of oil is 0.5 to 1%. Eighty lb. newly prepared cinnamon yields about 5½ oz. of heavy oil and 2½ oz. light oil.

"It is unfortunate that the greater part of the cinnamon oil exported is not genuine bark oil. Either leaves are added to bark when distilled, or cinnamon leaf oil is added to bark oil after distillation. . . . The active constituent of bark oil is cinnamic aldehyde; whereas that of leaf oil is eugenol, which is also the characteristic chemical constituent of oil of cloves. Leaf oil is sometimes designated 'clove oil.' "

For United States Government and Canadian standards see under *Cassia.*

Cloves

Cloves contain a volatile oil, fixed oil, resin, tannin, proteins, cellulose, pentosans, mineral elements, etc.

United States Government Standards require that cloves shall contain "not more than 5% of clove stems, not less than 15% of volatile ether extract, not less than 12% quercitannic acid (calculated from the total oxygen absorbed by the aqueous extract), not more than 7% of total ash, nor more than 0.5%

of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.001: "CLOVES, whole or ground, shall be the dried flower buds of the clove plant, and shall contain not more than

(a) 5% clove stems.
(b) 8% total ash.
(c) 0.5% ash insoluble in hydrochloric acid.
(d) 10% crude fiber.

and shall contain not less than 15% volatile ether extract."

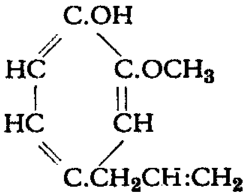
Published analyses* of cloves indicate considerable variation in the quantities of volatile and nonvolatile ether extracts present in this spice; minimum and maximum percentages reported, amongst others, as follows.

			Volatile Ether Extract %	*Nonvolatile Ether Extract* %
Penang Cloves	(1)	Min.	14.8	9.5
		Max.	17.2	12.0
	(2)	Min.	17.99	5.12
		Max.	20.04	6.61
Amboyna Cloves	(1)	Min.	18.00	8.2
		Max.	19.2	10.0
	(2)	Min.	20.42	6.39
		Max.	20.53	6.67
Zanzibar Cloves	(1)	Min.	12.1	8.00
		Max.	18.3	10.7
	(2)	Min.	17.82	6.24
		Max.	18.32	6.59

An analysis of Madagascar cloves by the author gave the following results.:

	Volatile Ether Extract %	*Nonvolatile Ether Extract* %	*Total Ether Extract* %	*Total Ash* %
Sample (a)	16.14	5.99	22.13	6.47
Sample (b)	17.26	6.30	23.56	6.41

The volatile oil of cloves contains from 70 to 90% of eugenol, empirical formula $C_{10}H_{12}O_2$, graphic formula



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* Winton, *Structure and Composition of Foods*, Vol IV, p. 296, John Wiley & Sons, Inc., New York, 1939.

Eugenol is a colorless, or faintly yellow, optically inactive liquid with the aromatic odor and pungent taste of cloves; it becomes darker and thicker on exposure to air. Eugenol is very slightly soluble in water, miscible with alcohol, chloroform, ether, and fixed oils. The color and solubility of the volatile oil of clove is similar to that of eugenol.

Other organic compounds reported present in the oil of cloves include eugenol acetate, caryophyllene, methyl *n*-amyl carbinol, methyl *n*-heptyl carbinol, methyl *n*-heptyl ketone, methyl benzoate, benzyl alcohol, furfuryl alcohol, and vanillin.

S. R. El-Beeb, M.S. Karawya, S.K. Wahba, and F.M. Ebeid (Fac. Pharm., Univ. Cairo) report that by gas-liquid partition chromatography oil of cloves had peaks of eugenol, methyl salicylate, limonene, carvone, α-pinene, and eucalyptol.*

Coriander

Coriander fruit contains a volatile oil, fixed oil, tannin, protein, cellulose, pentosans, calcium oxalate, mineral elements, etc.

United States Government Standards require that the dried fruit of coriander shall contain "not more than 7% of total ash, nor more than 1.5 per cent of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.022: "CORIANDER SEED shall be the dried fruit of the coriander plant and shall contain not more than

(a) 7% total ash.

(b) 1.5% ash insoluble in hydrochloric acid."

Coriander fruit contains from about .1 to 1% of volatile oil; it is a colorless or pale yellow liquid with the odor and flavor of the spice. The chief constituent of the oil is coriandrol (*d*-linalool), empirical formula $C_{10}H_{18}O$. In the pure state, coriandrol (*d*-linalool) is a colorless, fragrant liquid, very slightly soluble in water, soluble in alcohol, and in ether.

Other organic compounds reported present in the volatile oil of coriander include *d*-α-pinene, *dl*-α-pinene, β-pinene, β-terpinene, γ-terpinene, geraniol, borneol, and decylaldehyde.

G. M. Makarova and Yu. G. Borisyuk investigated the volatile oil of coriander and report linalool content 66.0%; and aldehyde content 0.2%. Fractional distillation separated 18% terpenes, such as α-pinene, β-pinene, dipentene, *p*-cymol, and α- and β-terpinenes.†

Yu. A. Akimov and V. G. Voronin report the following composition of coriander oil: α-pinene, camphene, β-pinene, myrcene, dipentene, *p*-

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* J. Pharm. Sci. (U. Arab Rep.) 3(1), 63-79 (1962); *CA.* 61.8.9351a.

† Farmatsevt, Za. (Kiev) 14, No. 3, 43-6 (1959); *CA.* 58.3.2320e.

cymene, linalool, camphor, linalyl acetate, borneol, geranyl acetate, and geraniol.*

The fixed oil content of coriander is about 20%. The fatty acids consist largely of petroselinic, oleic, palmitic, and linoleic acids.

Cumin

Cumin fruit contains a volatile oil, fixed oil, protein, cellulose, sugar, pentosans, calcium oxalate, mineral elements, etc.

United States Government Standards require that the dried fruit of cumin shall contain "not more than 9.5% of total ash, not more than 1.5% of ash insoluble in hydrochloric acid, nor more than 5% of harmless foreign matter."

Cumin fruit contains from about 2.5 to 4.5% of volatile oil. The chief constituent of the oil is cumaldehyde (*p*-isopropylbenzaldehyde; *p*-cuminic aldehyde), empirical formula $C_{10}H_{12}O$, structural formula $C_3H_7C_6H_4CHO$. Cumaldehyde, in the pure state, is a colorless to yellowish, oily liquid with a strong odor and flavor of cumin. It is insoluble in water, soluble in alcohol, and in ether.

Other organic compounds reported present in the volatile oil of cumin include dihydrocuminaldehyde, cuminyl alcohol, *dl*-pinene, *p*-cymene, and dipentene.

The fixed oil content of cumin is about 10%.

Curry Powder

Curry powder is a mixture or blend of a number of ground spices.

Canadian Government Standard, B.07.026: "CURRY POWDER shall be any combination of turmeric with spices and seasoning, and shall contain not more than 5% salt."

Dill

Dill fruit contains a volatile oil, fixed oil, protein, cellulose, calcium oxalate, mineral elements, etc.

United States Government Standards require that the dried fruit of dill shall contain "not more than 10% of total ash, nor more than 3 per cent of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.023: "DILL SEED shall be the dried fruit of the dill plant, and shall contain not more than

(a) 10 per cent total ash, and

(b) 3 per cent ash insoluble in hydrochloric acid."

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* *Gaz. Khromatogr.*, Moscow No. 3, 142-6 (1965) (Russ.); *CA.* 66. 21. 98424b.

Dill fruits contain from about 2 to 4% of volatile oil, colorless or pale yellow, and with the odor of the spice. The constituents of the oil are carvone, present in amount from about 40 to 50% or more, *d*-limonene, phellandrene, and probably other organic compounds. Carvone, empirical formula, $C_{10}H_{14}O$, a terpene ketone, is a colorless, oily liquid possessing an odor of caraway; it is very slightly soluble in water, soluble in alcohol, and in ether. The presence of carvone permits the use of dill as a substitute for caraway.

The fixed oil content of dill is about 17%.

Fennel

Fennel fruit contains a volatile oil, fixed oil, protein, cellulose, sugar, pentosans, calcium oxalate, mineral elements, etc.

United States Government Standards require that the dried fruit of fennel shall contain "not more than 9% of total ash nor more than 2% of ash insoluble in hydrochloric acid."

Fennel fruit contains from about 3 to 4% of volatile oil, colorless or pale yellow, with the characteristic odor and taste of the spice. The chief constituents of the oil are anethole, about 50 to 60%, and fenchone, about 20%. Anethole is described under anise; its anise-like odor is modified in fennel by the presence of fenchone and the other organic compounds present. Fenchone (*d*-fenchone), empirical formula $C_{10}H_{16}O$, a ketone, is an oily liquid with a bitter, camphoraceous flavor; insoluble in water, soluble in alcohol, and in ether.

Other organic compounds reported present in the volatile oil of fennel include *d*-α-pinene, *d*-α-phellandrene, dipentene, methyl chavicol, feniculin, anisaldehyde, and anisic acid.

I.U.W. Osisiogu (Univ. Nigeria, Nsukka) in a study of the fennel oil produced at Nsukka reported that the fruit of *Foeniculum vulgare*, of Indian origin and cultivated in Nigeria yielded 2.0-2.4% of essential oil, which contained ~86% anethole but no fenchone.*

The fixed oil content of fennel is about 10%. The fatty acids consist largely of petroselinic, oleic, linoleic, and palmitic acids.

I. M. Fefer investigated the solid part of the greasy oil from fennel seeds and reports 1.18% unsaponifiables, 1.52% saturated glycerides, probably of palmitic and stearic acids, and 97.3% glycerides of petroselinic acid.**

Fenugreek

Fenugreek seed contains a volatile oil, fixed oil, resin, protein, cellulose, starch, sugar, mucilage, mineral elements, etc.

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* *Planta Med.* 15(1), 30-1 (1967) (Eng); *CA.* 66. 24. 108169p

** *Farmatsevt. Zh.* (Kiev) 17, No. 1, 45-8 (1962); *CA.* 57.2.2354c.

The volatile oil content of fenugreek seed is very small, less than 0.02%. It is brown in color, and highly odorous. Very little is known about it.

The constituents of fenugreek seed include the alkaloids trigonelline, $C_7H_7O_2N$, and choline, $C_5H_{15}O_2N$, and a yellow coloring matter.

The fixed oil content is about 7%. The fatty acids consist largely of linoleic, oleic, and linolenic acids, with small amounts of palmitic, stearic, arachidic, and behenic acids.

Fenugreek seeds yield all of their odor and taste to alcohol.

Garlic

Garlic contains a volatile oil, fixed oil, protein, cellulose, mineral elements, etc.

The volatile oil content of garlic is very small, about 0.1%. It is a brownish-yellow liquid with a disagreeable, pungent odor. The constituents of the oil include diallyl disulfide, $C_6H_{10}S_2$ (about 60%), diallyl trisulfide, $C_6H_{10}S_3$ (about 20%), allyl propyl disulfide, $C_6H_{12}S_2$ (about 6%), a small quantity of diethyl disulfide, and probably diallyl polysulfide. Diallyl disulfide, a liquid, is said to possess the true garlic odor.

O. E. Schultz and H. L. Mohrmann, investigating the effectiveness of a number of mobile solvents for separating garlic oil constituents by thin-layer chromatography, report that between 9 and 14 oil constituents were separated. Diallyl disulfide was the main component of the oil.*

Canadian Government Standard, B.07.028: "GARLIC SALT shall be a combination of powdered dehydrated garlic and salt, shall contain not more than 75% salt, and may contain not more than 2% of an anti-caking agent."

Ginger

Ginger contains a small quantity of volatile oil, a fixed oil with pungent resinous matter, proteins, cellulose, pentosans, starch, mineral elements, etc.

United States Government Standards require that dried ginger shall contain "not less than 42% of starch, not more than 8% of crude fiber, not more than 1% of lime (CaO), not less than 12% of cold water extract, not more than 7% of total ash, not more than 2 per cent of ash insoluble in hydrochloric acid, nor less than 2% of ash soluble in cold water.

"Jamaica ginger. Ginger grown in Jamaica. It contains not less than 15% of cold water extract, and conforms in other respects to the standards for ginger.

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* *Pharmazie* 20 (6), 379-81 (1965); *CA.* 63.7.8116f.

"Limed ginger, bleached ginger. Whole ginger coated with carbonate of calcium. It contains not more than 4% of carbonate of calcium nor more than 10% of total ash, and conforms in other respects to the standards for ginger."

Canadian Government Standard, B.07.002: "GINGER, whole or ground

(a) shall be the washed and dried or decorticated and dried rhizome of the ginger plant;
(b) shall contain not more than 10% moisture;
(c) shall contain on the dry basis, not less than
  (i) 45% ginger starch.
  (ii) 13.3% cold water extractive as determined by the official method.
  (iii) 2% ash soluble in water.
(d) may contain not more than
  (i) 9% crude fiber.
  (ii) 1% calcium, calculated as calcium oxide.
  (iii) 7.5% total ash.
  (iv) 2% ash insoluble in hydrochloric acid."

B.07.003: "JAMAICA GINGER, whole or ground, shall be ginger grown in Jamaica, and shall conform to the standard provided in section **B.07.002** except that it shall contain, on the dry basis, not less than 16.6% cold water extractive as determined by the official method."

B.07.004: "LIMED GINGER or BLEACHED GINGER, whole or ground, shall be ginger coated with calcium carbonate and shall conform to the standard provided in **B.07.002** except that it shall contain not more than

(a) 2% calcium, calculated as calcium oxide.
(b) 11% total ash."

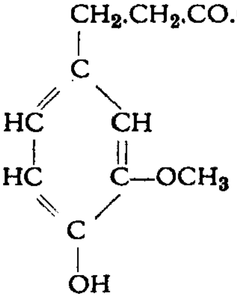
The determination of cold water extract is for the purpose of detecting exhausted or spent ginger, that is, ginger which has been previously employed in the making of products containing the flavoring principles of natural ginger. It is not likely that the spice will consist entirely of exhausted ginger, but the standard is there to detect adulteration by the admixing of exhausted ginger with the pure spice.

The author obtained a result of 16.29% in a determination of cold water extract in a random sample of Jamaica ginger of good quality.

Ginger contains from 1 to 3% of volatile oil. Oil of ginger is a yellowish, viscid liquid soluble in ether, sparingly soluble in alcohol, and almost insoluble in water. The chief constituent of oil of ginger is a sesquiterpene, zingiberene, $C_{15}H_{24}$. Other organic compounds reported present in the oil include α- and β-phellandrene, *d*-camphene, methyl heptenone, *n*-decylaldehyde, *n*-nonylaldehyde, borneol, cineole, linalool, citral, and a sesquiterpene alcohol zingiberol, $C_{15}H_{26}O$, an odorous compound from which the characteristic gingerlike odor of the oil is derived.

M. C. Nigam, Ishwar C. Nigam, and Leo Levi (Food and Drug Directorate. Ottawa. Canada) and K. L. Handa report that oil of ginger contains the following, unreported, constituents: cumene, β-pinene, myrcene, *p*-cymene, 2-selinene, β-elemene, 2-heptanol, 2-nonanol, and bornyl acetate.*

Oleoresin. The pungent principle of ginger is zingerone, present in the oleoresin obtained from the spice by extraction with acetone, alcohol, or ether. Zingerone, 3-methoxy-4-hydroxy-phenylethylmethylketone, empirical formula $C_{11}H_{14}O_3$, graphic formula



Consists, in the pure state, of white crystals, melting at 40 to 41° C; sparingly soluble in water, soluble in ether.

The oleoresin also contains shogaol, unidentified resins, and volatile oil. Shogaol, empirical formula $C_{17}H_{24}O_3$, is an unsaturated homologue of zingerone. The substance was obtained from ginger by Nomura of Japan who named it shogaol after "shoga", the Japanese name of ginger.

Laurel Leaves

Laurel leaves (Bay leaves) contain a volatile oil, fixed oil, protein, cellulose, pentosans, pigment, mineral elements, etc.

The principal constituent of the laurel leaf is its volatile oil, present in the amount of about 2%. The chief constituent of the oil is cineole, empirical formula $C_{10}H_{18}O$, a colorless liquid with a strong, aromatic, camphoraceous odor, and a cooling taste. Cineole is present in the oil in the amount of from about 45 to 50%. Other organic compounds reported present in the oil include α-pinene, α-phellandrene, *l*-linaloöl, *l*-α-terpineol, geraniol, eugenol, eugenol acetate, methyl eugenol, a number of esters, and acetic, isobutyric, and isovaleric acids.

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* Can. J. Chem. 42 (11), 2610-15 (1964); *CA.* 61.12.14463a.

Mace

Mace contains a volatile oil, fixed oil, resin, cellulose, pentosans, amylodextrin-starch, mineral elements, etc.

United States Government Standards require that mace shall contain "not less than 20% nor more than 30% non-volatile ether extract, not more than 10% of crude fiber, not more than 3% of total ash, nor more than 0.5% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.009: "MACE, whole or ground, shall be the dried arillus of *Myristica fragrans* Houttyn and shall contain not more than

(a) 7% crude fiber;
(b) 3% total ash.
(c) 0.5% ash insoluble in hydrochloric acid.

and the non-volatile ethyl ether extract, obtained after extraction of mace with petroleum ether, shall not exceed 5% and the sum of the nonvolatile extracts with petroleum ether and ethyl ether shall not exceed 33%."

The volatile oil is similar to that of nutmeg (page 200).

Marjoram

See *Sweet Marjoram.*

Mustard

White and black mustard seed contains a fixed oil, protein, cellulose, pentosans, mucilage, mineral elements, etc.

United States Government Standards for white and black mustard seed require that Sinapsis alba (white mustard) shall contain "no appreciable amount of volatile oil. It contains not more than 5% of total ash nor more than 1.5% of ash insoluble in hydrochloric acid.

"Brassica nigra (black mustard) . . . yield 0.6% of volatile mustard oil (calculated as allyl isothiocyanate). . . . not more than 5% of total ash, nor more than 1.5% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.024: "MUSTARD SEED shall be the seed of *Brassica Bois; B. hirta* Moench; *B. nigra* (L.) Koch; *B. juncea* (L.) Czern; or seed of species closely related to *B. nigra* and *B. juncea*, and shall contain

(a) not more than 1.5% ash insoluble in hydrochloric acid;
(b) not more than 8% total ash, on the oil-free basis."

B.07.005: "MUSTARD, MUSTARD FLOUR or GROUND MUSTARD shall be the powder made from mustard seed with the hulls largely removed, from which a portion of the fixed oil may be removed, and shall contain

(a) not more than 1.5% starch;
(b) not more than 8% total ash, on the oil-free basis; and shall yield
(c) not less than 0.40% volatile mustard oil as determined by the official method."

The expressed oil of mustard is a straw-colored or brownish-yellow, or greenish-brown liquid; it is present in the amount of about 24 to 26% in white mustard and of about 24 to 40% in black mustard. In white mustard oil the fatty acids consist largely of erucic and oleic acids, with small amounts of linoleic, linolenic, eicosenoic, behenic, palmitic, lignoceric, arachidic, stearic, and myristic acids. Black mustard oil has similar constituents but without the glyceride of stearic acid.

The most important constituent of white mustard seed is the glucoside, sinalbin. In the presence of water, sinalbin is broken down or decomposed by the action of an enzyme, myrosin, yielding sinalbin mustard oil, d-glucose, and *sinapine bisulfate. The reaction is said to proceed as follows:*

$$\underset{\text{sinalbin}}{C_{30}H_{42}O_{15}N_2S_2} + H_2O \longrightarrow \underset{\substack{\text{sinalbin}\\ \text{mustard oil}\\ (p\text{-hydroxybenzyl}\\ \text{isothiocyanate})}}{C_7H_7ONCS} + \underset{d\text{-glucose}}{C_6H_{12}O_6} + \underset{\substack{\text{sinapine acid}\\ \text{sulfate}}}{C_{16}H_{24}NO_5HSO_4}$$

Sinalbin mustard oil is only very slightly volatile with steam (sometimes reported as nonvolatile). It is almost odorless but has a pungent taste and causes blisters on the skin.

In black mustard seed the most important constituent is the glucoside sinigrin, or potassium myronate. When this substance is acted on by the enzyme myrosin in the presence of water it yields allyl isothiocyanate, *d*-glucose, and potassium hydrogen sulfate:

$$\underset{\text{potassium myronate}}{C_{10}H_{16}KNS_2O_9} + H_2O \longrightarrow \underset{\substack{\text{allyl}\\ \text{isothiocyanate}}}{CH_2{:}CH.CH_2.NCS} + \underset{d\text{-glucose}}{C_6H_{12}O_6} + \underset{\substack{\text{potassium}\\ \text{hydrogen}\\ \text{sulfate}}}{KHSO_4}$$

Allyl isothiocyanate is a volatile liquid, known as volatile oil of mustard, with a pungent, irritating odor, and an acrid taste. It causes blisters on the skin.

Nutmeg

Nutmeg contains a volatile oil, fixed oil, proteins, cellulose, pentosans, starch, mineral elements, etc.

The volatile oil is obtained by distillation, the fixed or expressed oil by pressure accompanied by heat.

United States Government Standards require that nutmeg shall contain "not less than 25% of nonvolatile ether extract, not more than 10% of crude fiber, not more than 5% of total ash, nor more than 0.5% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.010: "**NUTMEG,** whole or ground, shall be the dried seed of *Myristica fragrans* Houttyn, may have a thin coating of lime, shall contain not less than 25% non-volatile ether extract, and shall contain not more than

(a) 5% total ash.

(b) 0.5% ash insoluble in hydrochloric acid."

In a published table* of the composition of spices the following values for ether extract are given for nutmeg of unstated origin.

	Volatile Ether Extract %	*Nonvolatile Ether Extract* %
Minimum	2.56	28.73
Maximum	6.94	36.94

Ether extract determinations, using the continuous extraction method, made by the author on ground Grenada nutmeg gave the following results.

	Volatile Ether Extract %	*Nonvoratile Ether Extract* %	*Total Ether Extract* %
Sample (a)	3.13	38.54	41.67
Sample (b)	3.19	38.85	42.04

The figures shown for volatile ether extract in the latter determinations are undoubtedly low. Ground nutmeg suffers a rapid loss of volatile substances at ordinary temperatures; furthermore, the long period of ether volatilization at room temperature, and dessicator drying, following extraction is perhaps not the best process for this spice.

The volatile oil of nutmeg, also called oil of myristica, is a colorless or pale yellow liquid with the odor and taste of nutmeg. The oil is reported to contain a number of organic compounds including *d*- and *l*-α-pinene, β-pinene, *d*-camphene, dipentene, *p*-cymene, *d*-linaloöl, safrole, *dl*-α-terpineol, borneol, geraniol, and myristicin. The last mentioned substance is toxic and said to act as a narcotic.*

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* Winton, *Analysis of Foods*, 887, John Wiley & Sons, Inc., New York, 1945.

Ginette Jauregniberry and Robert Wolf (C.N.R.S., Gif-sur-Yvette, France) report the presence of (+)-sabinene in oil of nutmeg.*

Elwina A. Bejnarowicz and Ernst R. Kirch (Univ. of Illinois, Chicago) report that three East Indian and one West Indian varieties of nutmeg oil were analyzed by gas chromatography and that all four conatined α-pinene, β- pinene, limonene, *p*-cymene, 4-terpinenol, α-terpineol, and an unknown substance. Small amounts of terpinolene were found in two samples of East Indian nutmeg oil. Safrole and eugenol were present in all samples of East Indian nutmeg oil but not in West Indian nutmeg oil. Camphor was found only in West Indian nutmeg oil.**

Nutmeg yields from about 24 to 30% of fixed oil or expressed oil of nutmeg, also known as nutmeg butter, oil of mace. It is an orange-red to reddish-brown substance with the consistency of butter at ordinary temperatures. The chief constituent of the oil is trymyristin, $C_{45}H_{86}O_6$, the triglyceride of myristic acid. The remainder consists of the glycerides of oleic and linoleic acids, unsaponifiable matter, volatile oil, and resins.

Alexander T. Shulgin (Dow Chem. Co., Walnut Creek, Calif. U.S.A.) reports that the myristicin fraction of nutmeg oil after isomerization with alc. KOH was separated by gas chromatography to give methyl isoeugenol, *trans*-isomyristicin, and *cis*-isomyristicin.†

Onion

Onion contains a volatile oil, fixed oil, protein, cellulose, sugars, mineral elements, etc.

The volatile oil content of onion is very small, and little is known about its chemistry. The chief constituent of the oil is a disulfide with the empirical formula $C_6H_{12}S_2$. Other compounds containing sulphur may be present.

Canadian Government Standard, B.07.027: "ONION SALT shall be a combination of powdered dehydrated onion and salt, shall contain not more than 75% salt, and may contain not more than 2% of an anti-caking agent."

Origanum

Origanum contains a volatile oil, fixed oil, proteins, cellulose, pigment, mineral elements, etc.

This herb is usually classified as *Origanum vulgare* L. (common or wild marjoram) but morphologically it differs from the published descriptions of wild marjoram; it may be a variety of *Origanum vulgare*, or an entirely different species. The plant owes its usefulness as a culinary herb to its volatile oil.

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* *Bull. Soc. Chim.* France 1962, 1958-7; *CA.* 58.3.2318d.

** *J. Pharm. Sci.* 52(10). 988-93 (1963); *CA.* 60.1. 364a.

† Nature 297, 379 (1963); *CA.* 58.9.8846h.

In the literature concerning the volatile oil of origanum it would appear that oils made under this name are derived from a number of related species of Labiatae plants. In some origanum oils, thymol would appear to be the main constituent; in others, carvacrol. It is probable that some quantity of each of these compounds is present in the volatile oil of the herb under discussion, together with terpenes, alcohols, esters, etc.

Parsley

Parsley leaves contain a volatile oil, cellulose, pigment, mineral elements, etc.

The chemistry of the fruits of parsley seems to be fairly well known, but little is known about that of the leaves. The fruits of parsley are not employed as a spice. However, all parts of the parsley plant contain a volatile oil, and it is likely that the oil of the leaves differs little, if at all, from the oil of the fruit.

The herb owes its odor and taste to its volatile oil, which probably has for its main constituent a large proportion of the phenol ether, apiole. Apiole, structural formula $CH_2{:}CHCH_2C_6H(OCH)_2(CH_2O_2)$, known also as parsley camphor, crystallizes in the form of long needles; it is colorless and has a faint parsley odor. Myristicin, α-pinene, and small amounts of aldehydes, ketones, and phenols, are present in the fruit oil, and these compounds probably exist in the leaf oil.

Pepper

Pepper contains a volatile oil, fixed oil, resin, alkaloids, proteins, cellulose, pentosans, starch, mineral elements, etc.

United States Government Standards require that black pepper shall contain "not less than 6.75% of nonvolatile ether extract, not less than 30% of starch, not more than 7% of total ash, nor more than 1.5% of ash insoluble in hydrochloric acid." The standards also require that white pepper shall contain "not less that 7% of nonvolatile ether extract, not less than 52% of starch, not more than 5% of crude fiber, not more than 3.5% of total ash, nor more than 0.3% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.011: "**BLACK PEPPER or PEPPERCORN,** whole or ground,

(a) shall be the dried, immature berry of *Piper nigrum* L.;

(b) shall contain not less than

- (i) 6% non-volatile ether extract,
- (ii) 30% pepper starch;

(c) may contain not more than
- (i) 6% total ash.
- (ii) 0.9% ash insoluble in hydrochloric acid;

(d) in the case of ground black pepper shall contain all the parts of the berry in their normal proportions."

B.07.013: "**WHITE PEPPER,** whole or ground,

(a) shall be the dried, mature berry of *Piper nigrum* L. from which the outer coating or the outer and inner coatings are removed

(b) shall contain not less than
- (i) 7% nonvolatile ether extract,
- (ii) 52% pepper starch;

(c) may contain not more than
- (i) 5% crude fiber,
- (ii) 2.2% total ash,
- (iii) 0.3% ash insoluble in hydrochloric acid."

The author obtained the following results for ether extract determination:

	Volatile Ether Extract %	*Nonvolatile Ether Extract* %	*Total Ether Extract* %
Black pepper (origin unknown)	1.55	8.77	10.32
Black pepper (India)	2.05	8.79	10.84

And for ash, the following results:

	Total Ash %	*Ash Insoluble in Hydrochloric Acid* %
Black pepper (origin unknown)	6.39	1.49
Black pepper (India)	(a) 5.12	0.35
	(b) 5.19	not determined
	(c) 5.28	not determined

Pepper contains from 1 to 3% of volatile oil. It is a colorless or yellowish liquid; not pungent, but with the aromatic flavor of pepper; insoluble in water, soluble in about 10 to 15 parts of 90% alcohol, and in 3 to 10 volumes of 95% alcohol.

Organic compounds present in the volatile oil of pepper include α-pinene, β-pinene, *l*-α-phellandrene, β-caryophyllene, dihydrocarveol, and piperonal.*

C. J. Muller and W. G. Jennings (Univ. of California, Davis) identified the following as major compounds of the sesquiterpene hydrocarbon fraction of black pepper oil: δ-elemene, α-copaene, β-elemene, α-*cis*-bergamotene, α-santalene, α-*trans*-bergamotene, β-caryophyllene, α-humulene, β-selinene, α-selinene, β-bisabolene, δ-cadinene, and calamenene.**

The pungent principles of pepper are contained in its oleoresin, and consist of piperine, chavicine, piperidine. Piperine $C_{17}H_{19}NO_3$, an alkaloid, forms colorless, monoclinic needles from alcohol, at first tasteless but with a pungent aftertaste. Chavicine, $C_{17}H_{19}NO_3$, an isomer of piperine, is a yellowish, oily substance with a sharp, biting taste. Piperidine $(CH_2)_5NH$, an alkaloid, is a colorless liquid with the odor of pepper and a biting taste. To these, there has been added piperettine, a homologue of piperine, $C_{19}H_{21}O_3N$.†

Peppermint

Peppermint contains a volatile oil, fixed oil, resin, tannin, cellulose, pentosans, pigment, mineral elements, etc.

Oil of peppermint is a colorless to pale yellow liquid with a strong peppermint odor and pungent taste. It is very slightly soluble in water, soluble in 4 volumes of 90% alcohol.

The volatile oil of peppermint contains a large number of organic compounds. The chief constituents of the oil are *l*-menthol $C_{10}H_{20}O$, a secondary alcohol with a strong peppermint-like odor and a cooling taste; and *l*-menthone $C_{10}H_{18}O$, a ketone with an odor reminescent of peppermint, and a bitter taste less cooling than that of menthol. Other organic compounds present in the oil include terpinene, α-pinene, *l*-limonene, phellandrene, cadinene, *d*-menthone, menthyl acetate, menthyl isovalerate, amyl alcohol, acetaldehyde, isovaleric aldehyde, dimethyl sulfide, etc.

Poppy Seed

Poppy seed contains fixed oil, proteins, cellulose, pentosans, calcium oxalate, mineral elements, etc.

The most important constituent of poppy seed is the fixed oil, present in the amount of from 44 to 50%. It is straw- or pale-yellow in color, almost odorless, and agreeable in taste. The fatty acids consist largely of linoleic and oleic acids with smaller amounts of palmitic and stearic acids.

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* Hewitt, Ritter, Konigsbacher and Hasselstrom, paper presented at the 12th International Congress for Pure and Applied Chemistry, N. Y. C., Sept. 1951. (*The Essential Oils,* Ernest Guenther, 5, 143.)

** *J. Agr. Food Chem.* 15 (5), 762-6 (1967) (Eng); *CA* 67. 20. 93905v

† F. S. Spring and J. Stark, *CA* 44, 22, 10685f, 1950.

Rosemary

Rosemary contains a volatile oil, fixed oil, resin, tannin, proteins, cellulose, pentosans, pigment, mineral elements, etc.

Rosemary yields from about 0.3 to 2% of volatile oil, a colorless or pale yellow liquid with the odor of the herb, and a warm, camphoraceous taste. Organic compounds reported present in the oil include borneol (10 to 15 per cent) pinene, camphene, cineole, camphor, esters, etc.

Borneol (bornyl alcohol; 2-hydroxy camphane; 2-camphanol) empirical formula $C_{10}H_{18}O$, an alcohol, forms colorless crystals possessing a pungent, camphor-like odor and a burning taste.

E. R. El-Deeb, M. S. Karawya, S. K. Wahba, and F. M. Ebeid (Fac. Pharm., Univ. Cairo) report that by gas-liquid partition chromatography oil of rosemary had the peaks of camphene, α-pinene, bornyl acetate, and eucalyptol.*

Safflower (Mexican or American Saffron)

Safflower contains two coloring matters—namely, safflor-yellow and carthamin.

Safflor-yellow, empirical formula $C_{24}H_{30}O_{15}$, is the yellow coloring matter of safflower, and present in the amount of from 24 to 30%; it is soluble in water and in alcohol. Carthamin, also known as safflor-red, empirical formula $C_{21}H_{22}O_{11}$, a glucoside, is present in the amount of from 0.3 to 0.6. In the pure state, carthamin is a dark red, granular powder with a green luster; it is slightly soluble in water, soluble in dilute carbonate solutions, and insoluble in ether.

Saffron

Saffron contains a volatile oil, fixed oil, protein, cellulose, pentosans, an enzyme, mineral elements, etc.

United States Government Standards require that the dried stigmas of saffron shall contain "not more than 10% of yellow styles and other foreign matter, not more than 14 per cent of volatile matter when dried at 100°C, not more than 7.5% total ash, nor more than 1% of ash insoluble in hydrochloric acid."

Saffron contains from about 0.5 to 1% of volatile oil, a yellow, limpid, mobile liquid with an intense odor of saffron. The oil contains a glucoside, picrocrocin (saffron bitter) $C_{16}H_{26}O_7$, which yields on hydrolysis safranal and *d*-glucose.

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* *J. Pharm. Sci.* (U. Arab Rep.) 3(1), 63-79 (1962); *CA.* 61.8.9351a.

The coloring matter consists of crocin $C_{44}H_{64}O_{26}.H_2O$, a glucoside, which yields on hydrolysis crocetin and d-glucose. In the pure state, crocin consists of brown-red crystals, slightly soluble in cold water, freely in hot water; almost insoluble in absolute alcohol, ether, and in most common organic solvents. Crocetin is a dark red powder nearly insoluble in water, soluble in ether, alcohol, and in alkaline solutions.

Sage

Sage contains a volatile oil, fixed oil, resin, tannin, proteins, cellulose, pentosans, pigment, mineral elements, etc.

Canadian Government Standard, B.07.017: "**SAGE,** whole or ground, shall be the dried leaves of the sage plant, and shall contain not more than 12% stems (excluding petioles) and other foreign material."

Sage yields up to about 2.5% of volatile oil. The chief constituents of the oil are thujone and borneol. Thujone, empirical formula $C_{10}H_{16}O$, is a colorless, odorous liquid, responsible for the strong, characteristic smell of sage.

Other organic compounds reported present in the oil include salvene, *d*-*α*-pinene, cineole, and *d*-camphor.

Carl Heinz Brieskorn and Siegfried Dalferth (Univ. Wuerzburg, Germany) report that in the distillation of oil of sage of Dalmatian origin through a 35-cm Vigreux column (30 mm Hg, reflux ration 1:30) the fraction b. 130-53° was rich in 2-methyl-3-methylene-5-heptene. Its possible biogenesis from thujone is discussed by the authors.*

Savory

Savory contains a volatile oil, fixed oil, proteins, cellulose, pentosans, sugar, pigment, mineral elements, etc.

Savory yields about 1% of volatile oil. The chief constituent of the oil is carvacrol, empirical formula, $C_{10}H_{14}O$, a colorless to pale yellow liquid with a pungent, thymol odor (it is isomeric with thymol).

Other organic compounds present in the volatile oil of savory include *p*-cymene, and probably pinene and dipentene.

Sesame

Sesame seed contains fixed oil, proteins, cellulose, pentosans, calcium oxalate, mineral elements, etc.

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* *Ann.* 676. 171-4 (1964); *CA.* 61.12.14463d.

The chief constituent of sesame seed is the fixed oil, present in the seed to the extent of 57% or more, but usually from about 44 to 54%. The fatty acids consist largely of oleic and linoleic acids with small amounts of palmitic, stearic, arachidic, and myristic acids.

The unsaponifiable matter includes sesamin, empirical formula $C_{20}H_{18}O_6$, and sesamolin $C_{20}H_{18}O_7$, the former a complex cyclic ether, the latter with the characteristics of a glycoside.

Sesame oil is pale yellow in color, almost odorless, and possesses a bland taste. It is insoluble in water, slightly soluble in alcohol, and soluble in chloroform and ether.

Spearmint

Spearmint contains a volatile oil, fixed oil, resin, tannin, cellulose, pentosans, pigment, mineral elements, etc.

The volatile oil of spearmint is a colorless, yellow or greenish-yellow liquid with the characteristic spearmint odor and taste. It is very slightly soluble in water, soluble in an equal volume of 80% alcohol. The oil contains *l*-carvone (50% or more); *l*-limonene, *l*-phellandrene, and probably other terpenes; esters, etc.

The ketone, *l*-carvone, empirical formula $C_{10}H_{14}O$, in the pure state, is a colorless liquid with an odor of caraway, in which fruit it also occurs.

Thomas F. Burks and Gunnar Gjerstad (Univ. of Texas, Austin, U.S.A.) investigating the components of spearmint oil report that the presence of cineole, a-pinene, and linalool was conclusively demonstrated.*

Star Anise

Star anise contains a volatile oil, fixed oil, resin, protein, cellulose, pentosans, mineral elements, etc.

United States Government Standards require that star anise shall contain "not more than 5% of total ash."

Star anise yields about 3 % of volatile oil, colorless or pale yellow, with an aromatic odor, and a sweet, agreeable taste.

The chief constituent of the oil is anethole (described under anise); it constitutes from about 85 to 90 % of the oil. A large number of other organic compounds are reported present in the volatile oil of star anise including α- and β-phellandrene, *d*-α-pinene, *p*-cymene, *l*-limonene, α-terpineol, methyl chavicol, hydroquinone, monoethyl ether, safrole, anisketone, feniculin, and anisoxide.

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* *J. Pharm. Sci.* 53(8), 964-5 (1964); *CA.* 61.10. 11844f.

Friedrich Porsch, Heinz Farnow, and Horst Winkler, investigating a specimen of the volatile oil from Hanoi, North Vietnam, report the presence of 88% *trans*-anethole and 5% (−)-limonene. Other constituents, present in amounts of 0.1 to 1%, were 8-hydroxy-*p*-cymol, terpinolene, myrcene, *l*-terpineol, (+)-α-terpineol, (−)-β-pinene, (+)-α-pinene, Δ^3-carene, a-phellandrene, cineole, and linalool. Traces of camphene, *p*-cymol and *l*-methyl-4-isopropenylbenzene were also determined. They observe that "Most of these compounds are reported for the first time; conversely, a number of compounds reported by other authors were not identified."*

Star anise contains about 20% of fixed oil; it contains the glycerides of stearic, linoleic, palmitic, and oleic acids.

Sweet Basil

Sweet basil contains a volatile oil, fixed oil, proteins, cellulose, pigment, mineral elements, etc.

The volatile oil of sweet basil is yellowish to greenish in color. The odor is aromatic. The chief constituents of the oil are methyl chavicol and *d*-linaloöl. Of the other organic compounds present in the volatile oil of sweet basil cineole and eugenol have been identified.

Methyl chavicol, empirical formula $C_{10}H_{12}O$, a phenol ether, an isomer of anethole, is a colorless liquid with an anise-like odor. Linaloöl, empirical formula $C_{10}H_{18}O$, an alcohol, is a liquid with a very pleasant odor reminiscent of lily of the valley. Cineole has a camphor-like odor, and eugenol a clove-like odor.

D. Ivanov, S. Chorbadzhiev, and Ch. Iordanov (Univ. Sofia, Bulg.), investigating the composition of Bulgarian basil oil, report that the Bulgarian basil resembles closely the American-type oil of sweet basil, containing linaloöl, methyl chavicol, 1,8-cineole, eugenol, geraniol, *p*-cymene, myrcene, and a trace of cinnamic acid.**

D. Ivanov, S. Chorbadzhiev, and Ch. Iordanov report the following constituents in the composition of Bulgarian basil oil: l-linaloöl (main constituent), 1,8-cineole, eugenol, geraniol, *p*-cymene, myrcene, α-terpineole, and sesquiterpene hydrocarbons.†

Sweet Marjoram

Sweet marjoram contains a volatile oil, fixed oil, proteins, cellulose, pentosans, pigment, mineral elements, etc.

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* *Dragoco Rept.* 12(2), 27-9 (1965); *CA.* 63.1. 428d.

** *Perfumery Essential Oil Record* 55(11), 717-19 (1964); *CA.* 62.12.14418f.

† *God. Sofi. Univ., Khim. Fak.* 59 229-36, (1964-1965) (Pub. 1966) (Bulg); *CA.* 67. 23. 111332n.

United States Government Standards require that the dried leaves, with or without a small proportion of the flowering tops, of sweet marjoram shall contain "not more than 16% of total ash, not more than 4.5% of ash insoluble in hydrochloric acid, nor more than 10% of stems and harmless foreign material."

Canadian Government Standard, B.07.025: "MARJORAM, whole or ground,

(a) shall be the dried leaves of the marjoram plant;
(b) may contain a small proportion of the flowering tops of the marjoram plant;
(c) shall contain not more than
  (i) 10% stems and foreign material,
  (ii) 16% total ash,
  (iii) 4.5% ash insoluble in hydrochloric acid."

Sweet marjoram contains from about .7 to 3.5% of volatile oil. It is a yellow or greenish-yellow liquid, insoluble in water, soluble in 2 volumes of 80% alcohol, in ether, and in chloroform. Not a great deal is known about the chemistry of this oil. It is reported to consist of about 40% of terpenes, of which terpinene, empirical formula $C_{10}H_{16}$, constitutes the greater part, together with *d*-*α*-terpineol, terpinen-4-ol, and other compounds not yet identified. Terpinene has a lemon-like odor, terpineol a lilac-like odor; these undoubtedly contribute much to the pleasing fragrance of this herb.

V. N. Vashist, M. C. Nigam, K. L. Handa (Regional Res. Lab. Jammu, India) report that the oil distilled from *Majorana hortensis* of European origin grown in Kampur, India, contains a-terpineol, 26.7%; *α*-terpinene, 24.1%; geraniol, 19%; 4-terpinenol, 10.2%; eugenol 8%; and linalool 5.6%.*

Guenther Lossner (Karl-Marx-Univ., Leipzig, Ger.) reports that steam distillation of French leaf marjoram yielded 1.3% (av.) essential oil based on dry material. Thin-layer, column, and gas chromatography of the steam-distilled oil revealed a high proportion of *cis*-sabinene hydrate (25%) besides *trans*-sabinene hydrate (7%). Lossner reports *cis*-sabinene hydrate, when purified by sublimation, as having a strong spicy marjoram-like odor.†

Tarragon

The leaves of tarragon contain a volatile oil, cellulose, pigment, mineral elements, etc.

The chief constituent of the volatile oil of tarragon is reported to be methyl chavicol. Ocimene, phellandrene, and *p*-methoxycinnamaldehyde have also been reported. Methyl chavicol (estragole, chavicol methyl ether, *p*-allylanisole), empirical formula $C_{10}H_{12}O$, structural formula $CH_2:CHCH_2\text{-}C_6H_4OCH_3$, a phenol ether, is a colorless liquid with an odor slightly reminiscent of anise.

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* *Riechstoffe Aromen* 13, 61-2 (1963); *CA.* 58.13. 13705g.

† *Pharmazie* 22(1), 51-4 (1967) (Ger); *CA.* 66. 26. 118799h.

Thyme

Thyme contains a volatile oil, fixed oil, proteins, tannin, cellulose, pentosans, pigment, mineral elements, etc.

United States Government Standards require that the dried leaves of thyme shall contain "not more than 14% of total ash, nor more than 4% of ash insoluble in hydrochloric acid."

Canadian Government Standard, B.07.018: "THYME, whole or ground, shall be the dried leaves and flowering tops of the thyme plant and shall contain not more than

(a) 12% total ash.
(b) 4% ash insoluble in hydrochloric acid."

The volatile oil of thyme is a colorless to yellowish-reddish liquid with a pleasant odor characteristic of the herb, and a sharp taste.

The chief constituent of the oil is thymol (thyme camphor; 3-methyl-6-isopropylphenol), empirical formula $C_{10}H_{14}O$. In the pure state, thymol consists of colorless, translucent crystals possessing an aromatic, thyme-like odor and a pungent taste.

Other organic compounds reported present in the volatile oil of thyme include carvacrol, *l*-linaloöl, *l*-borneol, geraniol, amyl alcohol, β-γ-hexenol, terpinen-4-ol, β-pinene, *p*-cymene, γ-terpinene, caryophyllene, and camphene.

Turmeric

Turmeric contains a volatile oil, fixed oil, resin, a coloring matter, protein, cellulose, pentosans, starch, mineral elements, etc.

Canadian Government Standard, B.07.016: "TURMERIC, whole or ground, shall be the dried rhizome of *Curcuma longa* L."

On distillation, turmeric yields from about 1.3 to 5.5% of volatile oil, orange-yellow in color, slightly fluorescent, and aromatic. Formerly it was said that the oil contained an alcohol, turmerol, and a ketone, curcumone. It is now reported that the main fraction of the volatile oil consists of a monocyclic hydroaromatic ketone, turmerone $C_{15}H_{22}O$, and an aromatic ketone, *ar*-turmerone, or dehydroturmerone, $C_{15}H_{20}O$.*

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* Pfau, *Helv. Chim. Acta* 15 (1932), 1482; Rupe, Clar, Pfau, and Plattner, *Helv. Chim. Acta* 17(1934), 380; Ernest Guenther, *The Essential Oils*, vol.2, p.450, Van Nostrand, New York.

Other organic compounds reported present in the oil include *d*-α-phellandrene, *d*-sabinene, zingiberene, cineole, borneol, etc.

The coloring matter of turmeric is curcumin, 1,7-bis (4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione, empirical formula $C_{21}H_{20}O_6$, structural formula $[(CH_3O)(OH)C_6H_3CH{:}CHCO]_2CH_2$. The pure substance is an orange-yellow crystalline powder, insoluble in water, slightly soluble in ether, soluble in alcohol and in glacial acetic acid; it is also soluble in alkalies with a reddish-brown color.

Curcumin assists in the identification of turmeric starch. The yellow, pasty masses of starch become reddish-brown with sodium, potassium, and ammonium hydroxides; they become crimson with concentrated sulfuric acid.

XLIV. pH DETERMINATIONS

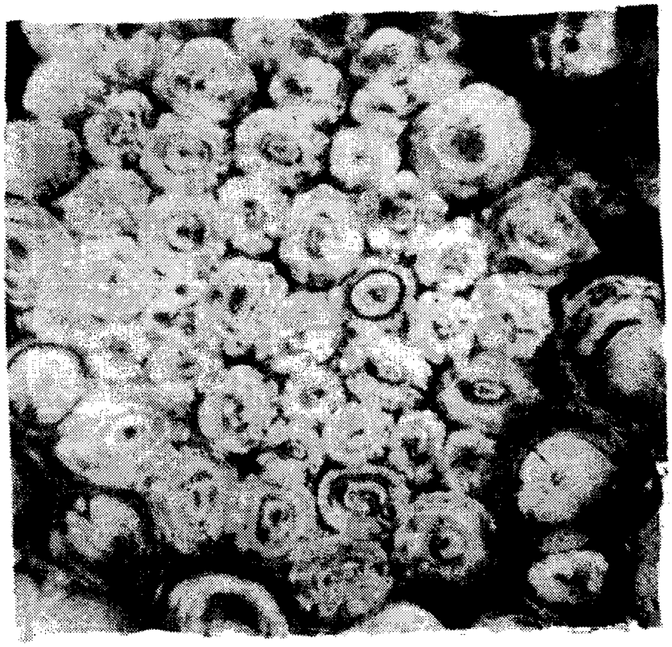
The following determinations were made by the author, employing a Beckman pH recording meter. Samples consisted of 2 g of the ground spice contained in 25 cc of distilled water at 25°C.

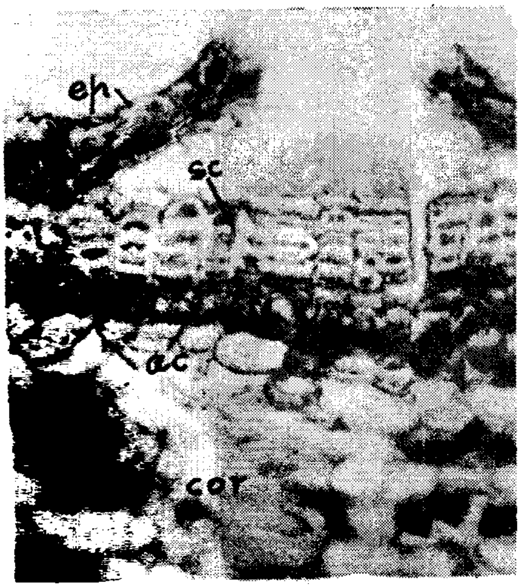
		pH
Allspice	Jamaica	4.82
	Jamaica, residue following ether extraction	4.82
Allspice	Mexican	5.4
Cassia	Honan	4.32
	Yunan	4.53
	Kwangsi	5.0
	Saigon	4.4
	Batavia	4.6
Cinnamon	Ceylon	4.6
Cloves	Madagascar	4.1
	Zanzibar	4.12
Ginger	Jamaica No. 1	6.2
	Jamaica No. 2	6.08
	African	6.2
Mace		4.6
Nutmeg	East Indies	5.85
	West Indies	5.85
Pepper	black	6.4, 6.42, 6.72, 7.1, 7.18, 7.3, 7.5
Pepper	white	5.2, 6.1, 6.02

No further work was done, and this information is given here for those who may be interested in the hydrogen ion concentration of the spices. It may have some significance, use, and value in checking the purity of ground spices.

Part 3

PHOTOMICROGRAPHS





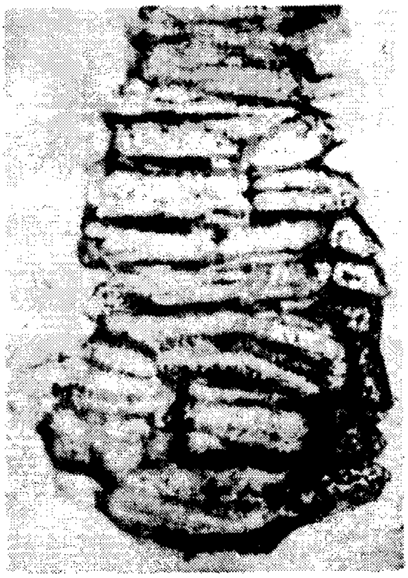
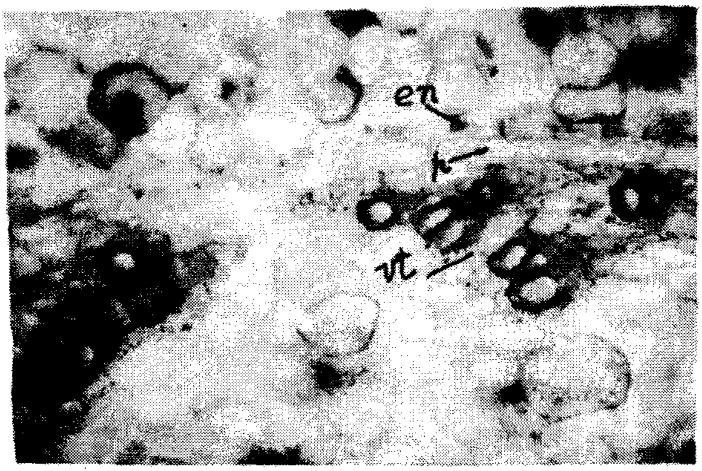
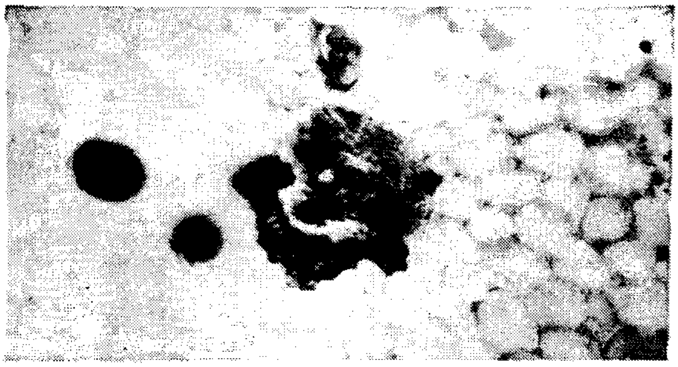


Fig. 41. Yunan Cassia (*top*). Phloem fibers (cross section) × 500.

Fig. 42. Kwangsi Cassia. (*left*). Stone cork, *sc*; arch cells, *ac* (× 150); epidermis, *ep*; cortex, *cor*.

Fig. 43. Saigon Cassia (*right*). Group of stone cells pericycle zone (× 150).





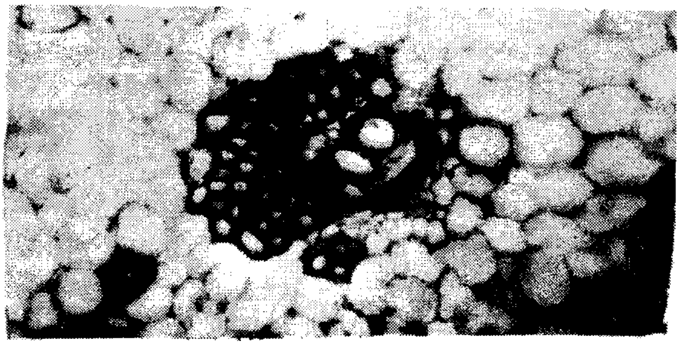
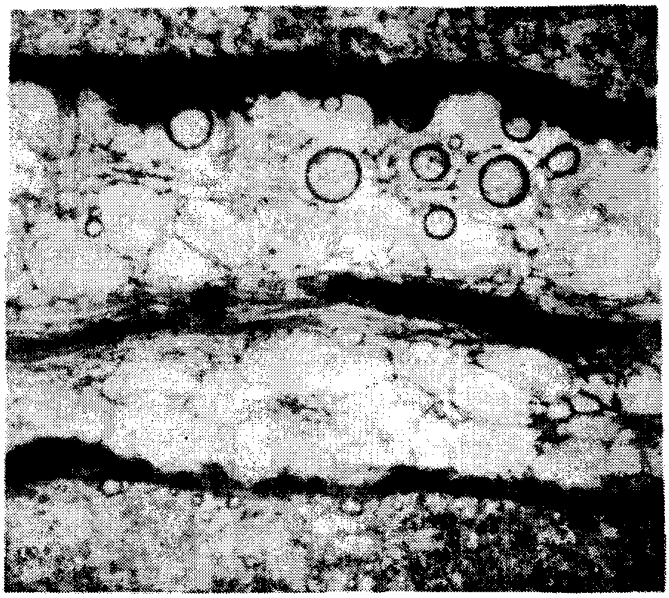
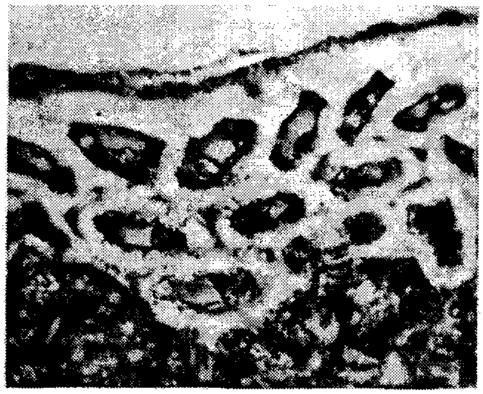


Fig. 44 Turmeric × 100 (*top*). Endodermis, *en*; pericycle, *p*; vascular tissue, *vt*.

Fig. 45. Ginger × 100 (*middle*). Fibrovascular tissue, cortex.

Fig. 46. Ginger × 100 (*bottom*). Fibrovascular tissue, central cylinder.





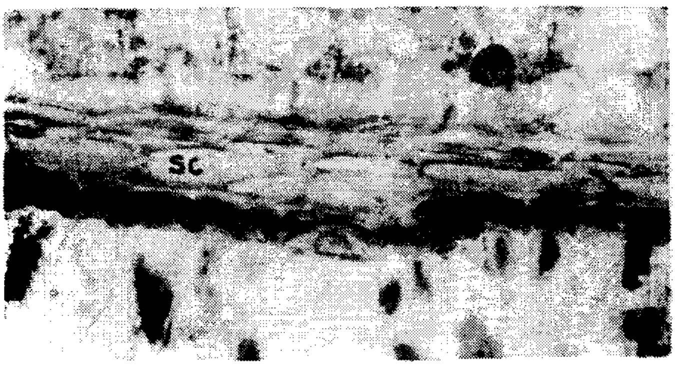
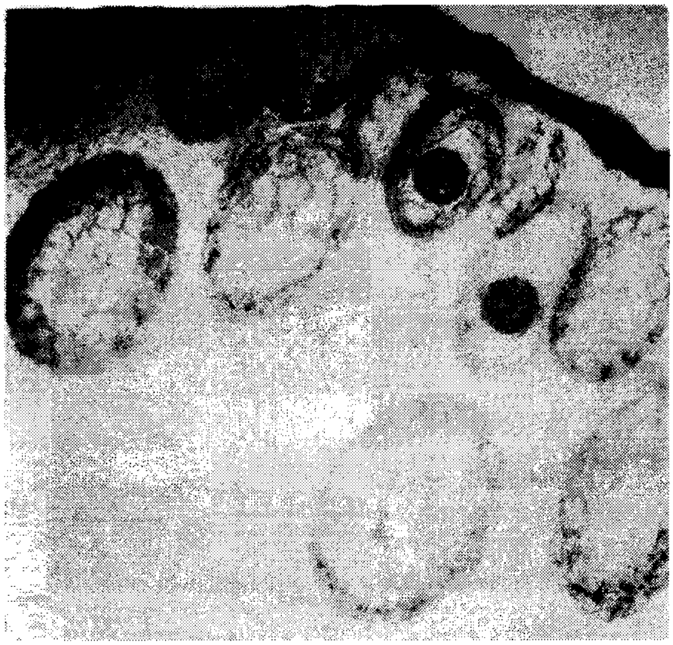


Fig. 47. Nutmeg × **100** (*top*). Oil cells of perisperm.

Fig. 48. Mace, Grenada × **500** (*middle*). Epidermis and hypodermis.

Fig. 49. Pepper × **500** (*bottom*). Seed coat, *sc*; pigment removed.



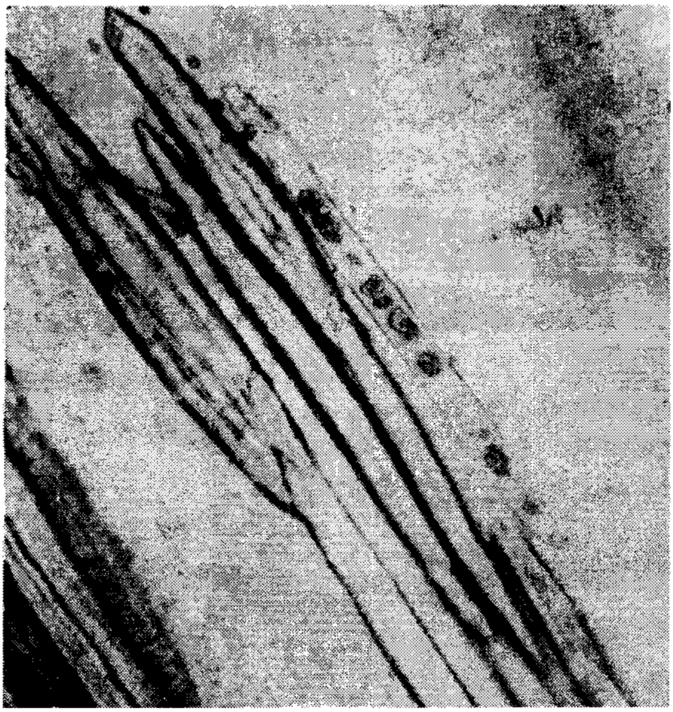
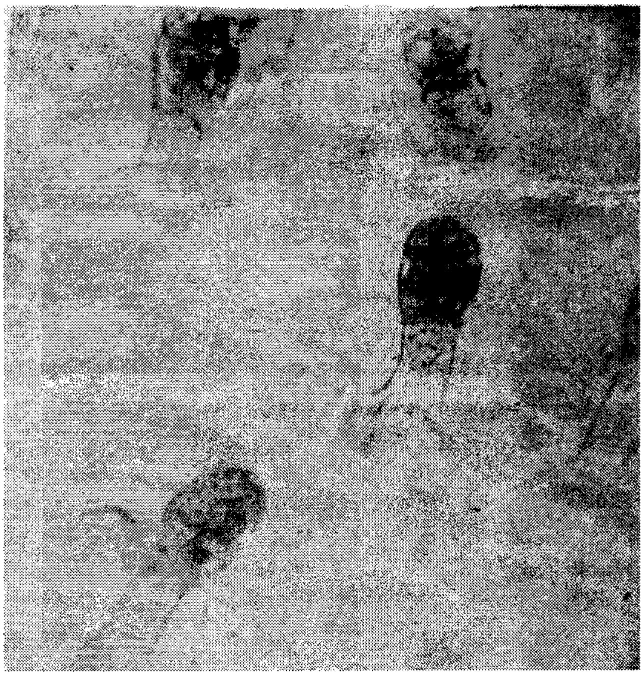


Fig. 50. Clove × 100 (*top*). Oil cavities.

Fig. 51. Clove × 150 (*bottom*). Fibers and crystal fiber.



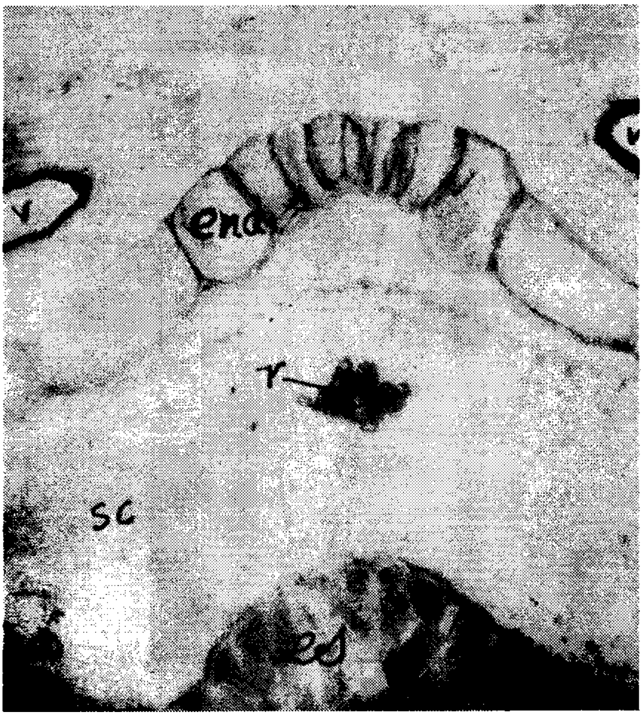
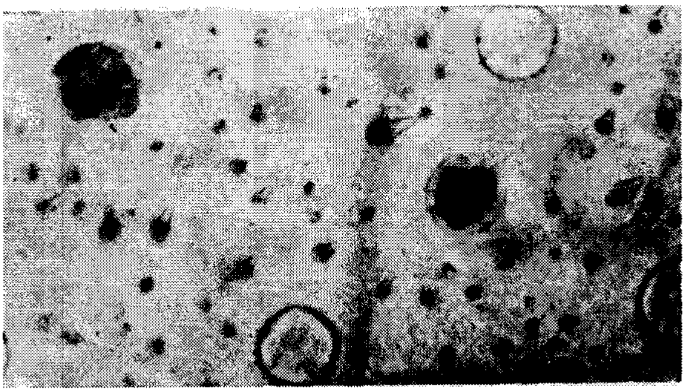
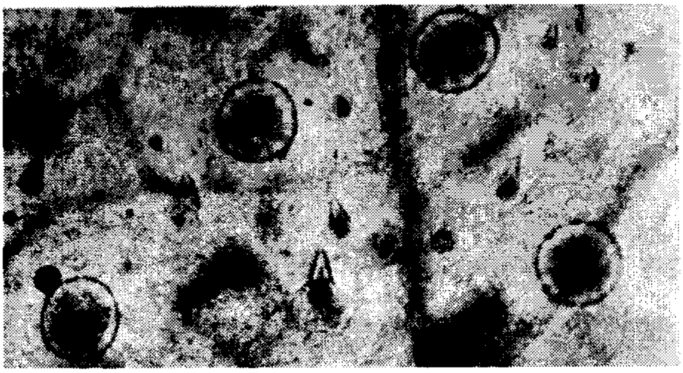


Fig. 52. Chile Ancho ×**250** (*top*). Capitate hairs of calyx.

Fig. 53. Caraway ×**250** (*bottom*). Commissural side—vittae, *v*; endocarp, *end*; seed coat, *sc*; raphe, *r*; endosperm, *es*.





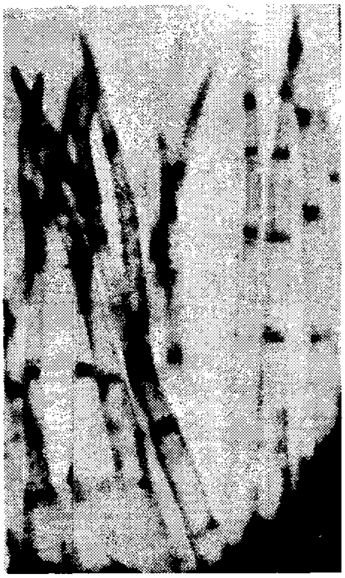
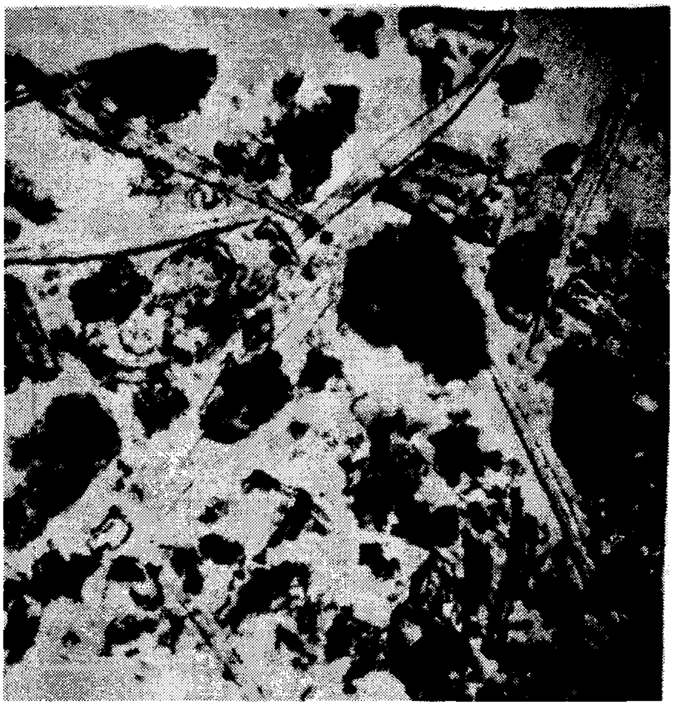


Fig. 54. **Savory** × **100** (*top*). Upper surface, hairs and oil glands.

Fig. 55. **Savory** × **100** (*middle*). Lower surface, hairs and oil glands. Note—hairs more numerous on the upper surface.

Fig. 56. **Savory** × **100** (*bottom*). Throat hairs of calyx.



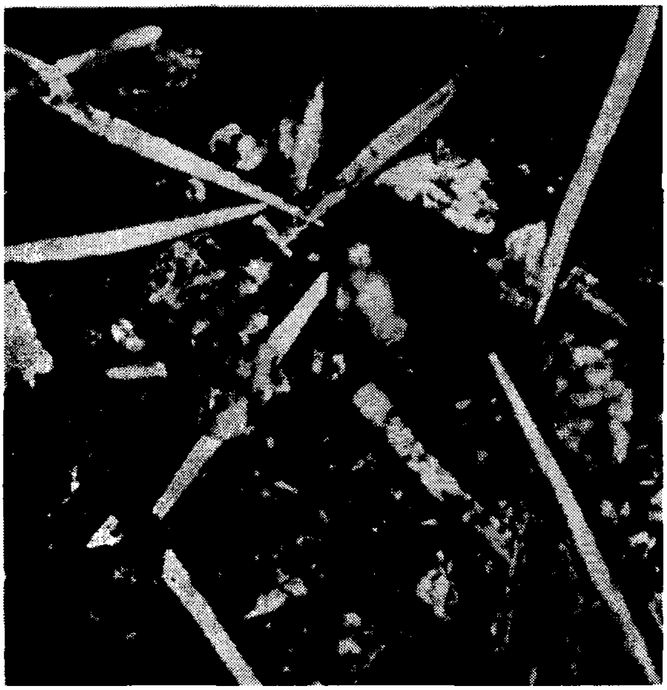
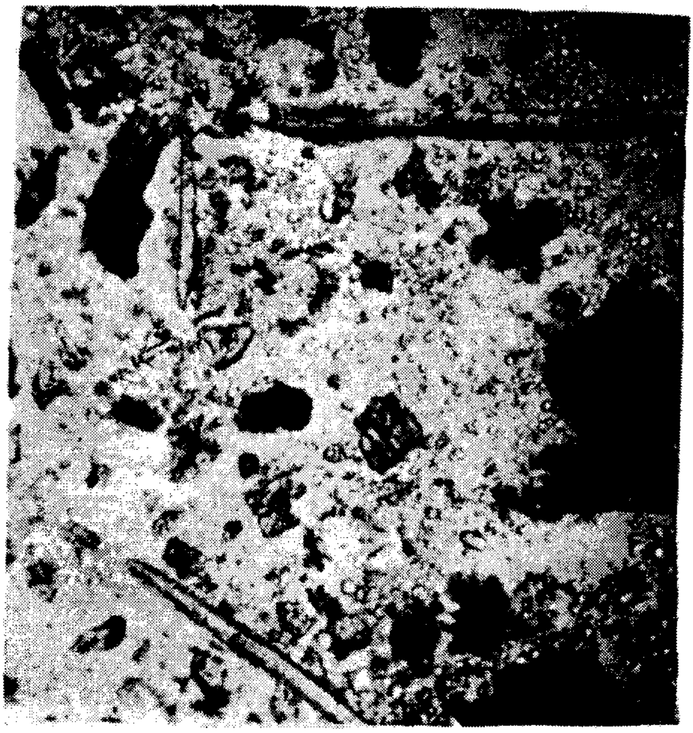


Fig. 57. Ground Ceylon Cinnamon × **100** (*top*). Transmitted light.
Fig. 58. Ground Ceylon Cinnamon × **100** (*botom*). Polarized light.



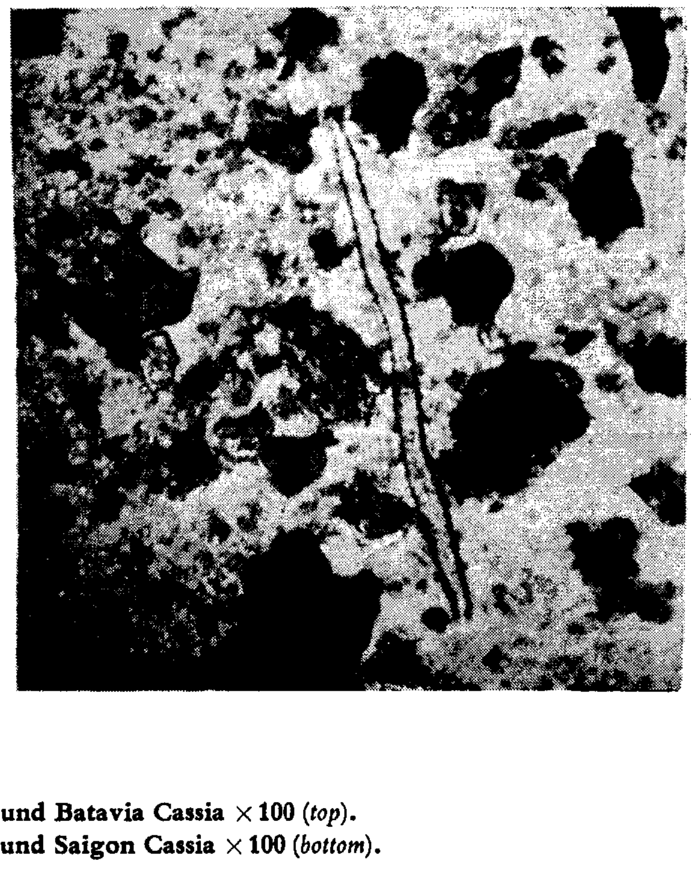
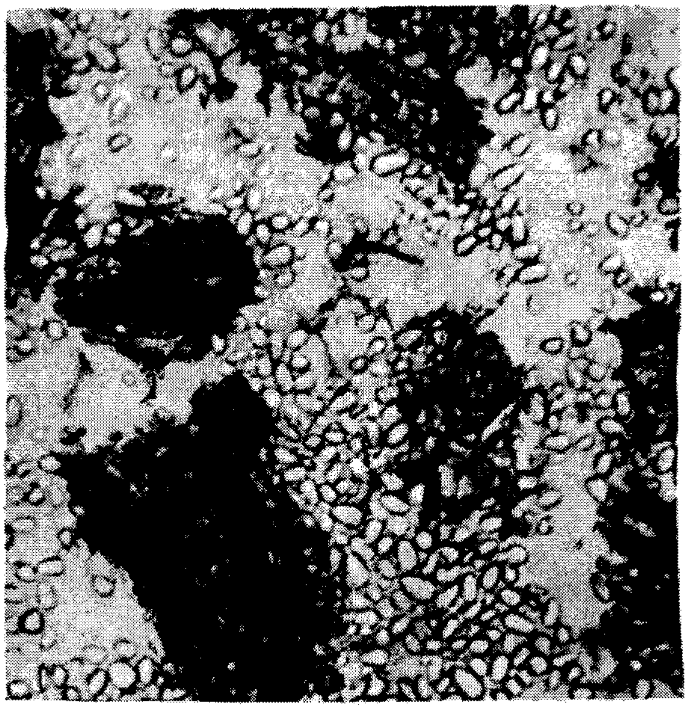


Fig. 59. Ground Batavia Cassia × 100 (*top*).
Fig. 60. Ground Saigon Cassia × 100 (*bottom*).



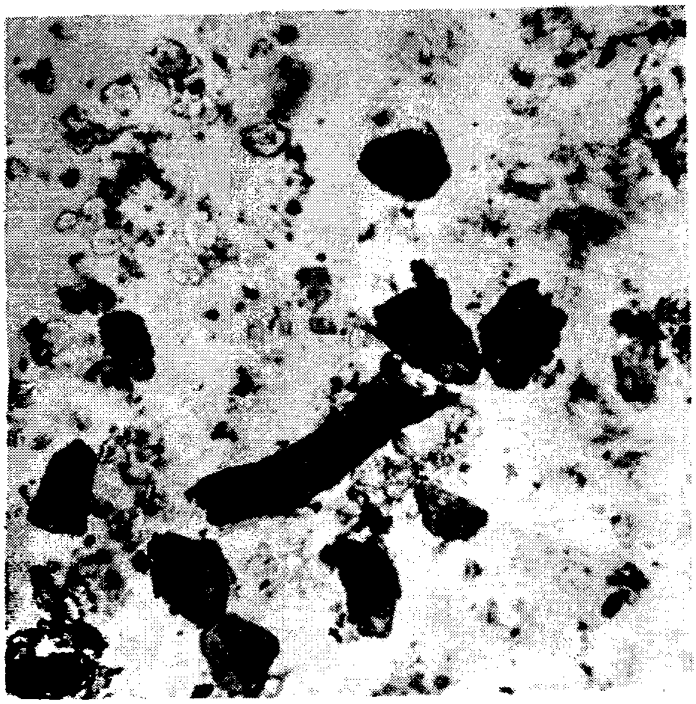
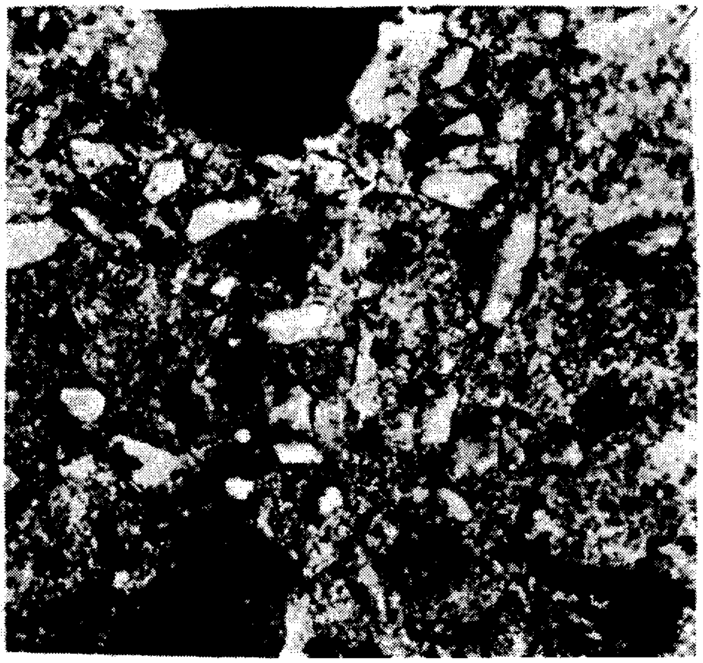


Fig. 61. **Ground Ginger** × **100** (*top*).
Fig. 62. **Ground Turmeric** × **100** (*bottom*).



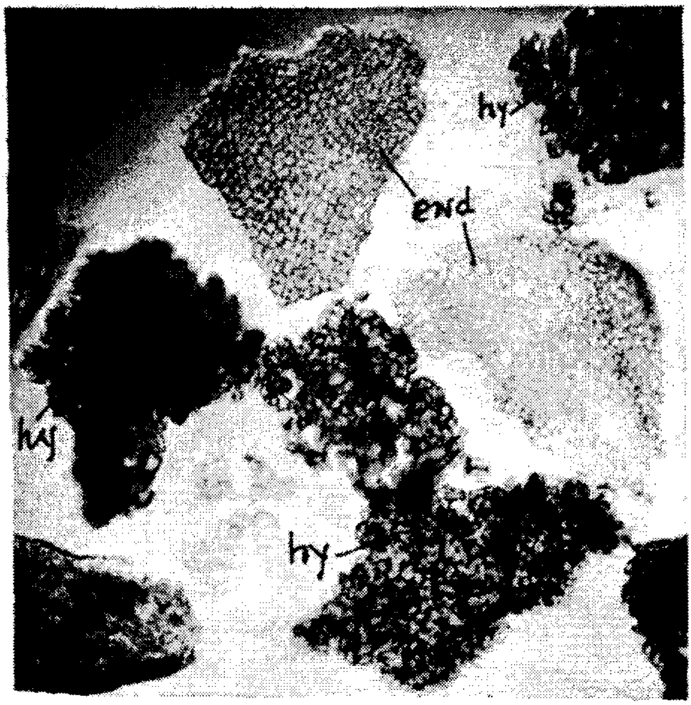
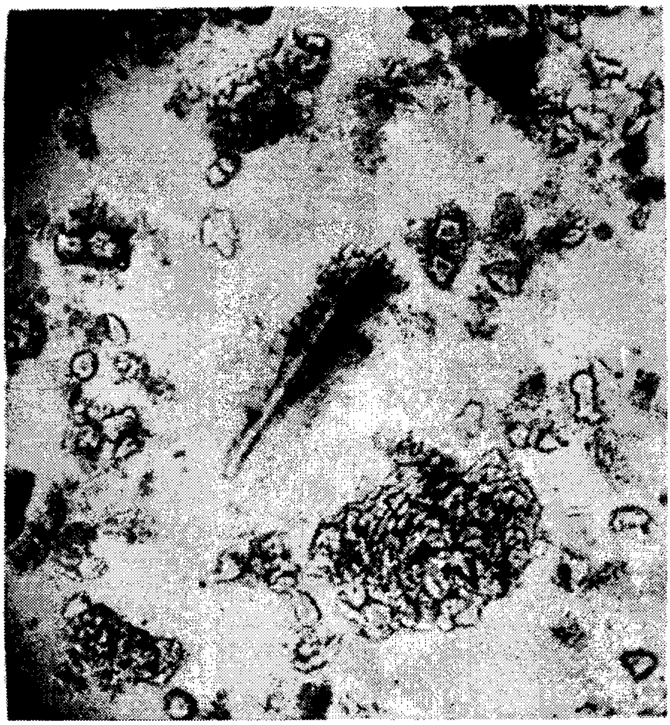


Fig. 63. Ground Black Pepper × **100** (*top*).

Fig. 64. Black Pepper × **100** (*bottom*). Fragments of hypodermis, *hy*, and endocarp, *end*.



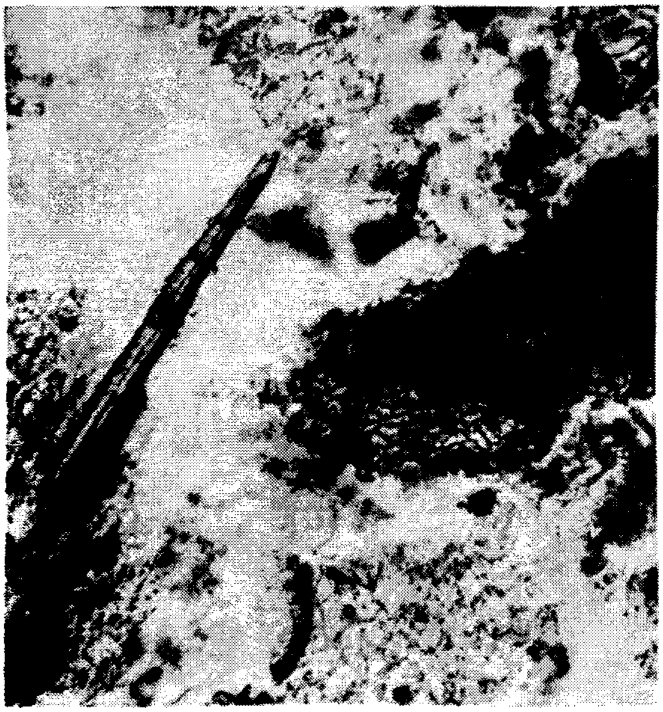
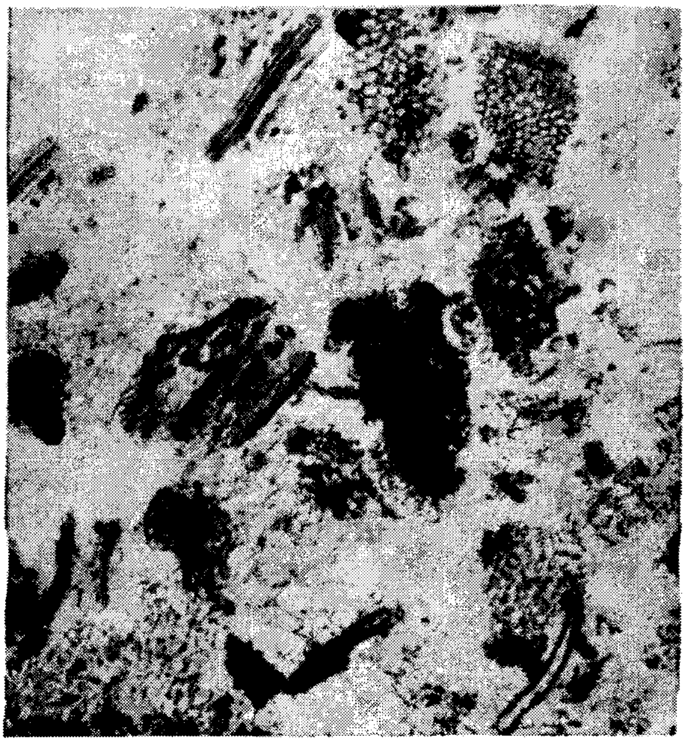


Fig. 65. Ground Allspice × **50** (*top*).
Fig. 66. Ground Cloves × **100** (*bottom*).



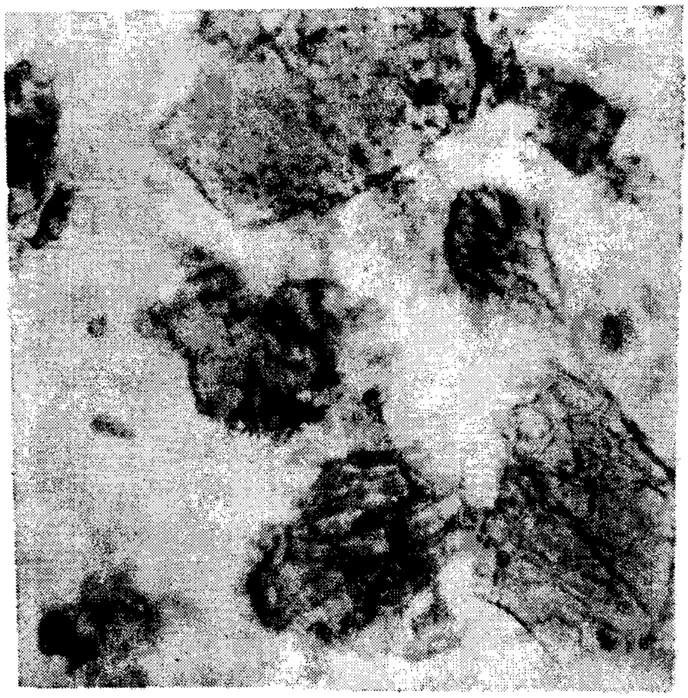


Fig. 67. Ground Cloves ×100 (*top*).
Fig. 68. Ground Paprika×100 (*bottom*).

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GLOSSARY

Acuminate—Leaf apex tapering to a sharp point.
Acute—Leaf apex broadly coming to a sharp point.
Adnate—United.
Androecium—The stamens collectively.
Annulate—Having rings or ringlike segments.
Aril—A protective covering enveloping the seed.
Axil—The angle formed at the juncture of leaf and stem.
Axillary—Situated in the axil of a leaf.
Bicarpellate—Having two carpels.
Bilabiate—Two-lipped.
Bilocular—Two-celled.
Bilobed—Having two lobes.
Bract—Modified leaf, as of an inflorescence.
Calyx—The sepals collectively form the calyx.
Calyx Tube—The tube of a gamosepalous calyx.
Campanulate—Having the shape of a bell.
Capitate—Shaped like a head, as in gland-tipped hairs.
Carpel—A simple pistil or a unit of a compound pistil.
Collenchyma—Cells with cellulose thickening laid down in longitudinal strips on the walls, chiefly in corners; supporting tissue.
Commissure—The surface by which one carpel joins another as in the *Umbelliferae* fruits.
Commissural—Pertaining to the commissure.
Conduplicate—Folded together lengthwise.
Coriaceous—Leathery in texture.
Corolla—The petals collectively.
Cotyledons—The first leaves of the embryo as formed in the seed.
Cortex—The cellular tissue between the epidermis and the endodermis or the pericycle of roots and stems.
Crenate—Scalloped, or dentate with the teeth much rounded.
Cruciform—Cross-shaped.

Cuticle—A protective layer of waxy substance, chiefly cutin, covering the epidermis.

Cutinized—Deposition of cutin in cell walls; cutin associated with cellulose.

Cyme—A flat-topped inflorescence in which the central flowers bloom first.

Decompound—More than once compound or divided.

Dentate—Having teeth which point outward.

Didynamous—Stamens in two pairs of unequal length.

Dioecious—Unisexual, with staminate flowers on one plant and carpellate on the other.

Discoid—Disk-shaped; round and flat.

Elliptical—Similar to oblong but with continuously rounding sides; like an ellipse.

Endocarp—The inner layer of the pericarp; the inner layer of a fruit.

Endosperm—The cellular tissue in which food is stored in an albuminous seed. In an albuminous seed the food store is outside the embryo. In an exalbuminous seed the food store is contained in the embryo.

Ensiform—Sword-shaped.

Epicarp—The outer layer of the pericarp.

Epigynous—Growing from the top of the ovary.

Exocarp—The outer layer of the pericarp; the outer layer of a fruit.

Filament—The part of the stamen which supports the anther.

Gamopetalous—With united petals; sympetalous.

Gamosepalous—With united sepals; synsepalous.

Glabrous—Without hairs.

Glandular-punctate—Dotted with glands.

Glaucous—Having a whitish coating or bloom.

Gynoecium—A carpel or aggregation of carpels.

Herbaceous—Having the character of a herb; not woody.

Hilum—Scar on a seed, marking the point where the seed broke from the stalk. In starch, the original core around which the layers of starch were laid down.

Hispid—With bristly hairs.

Incised—Cut sharply or irregularly, more or less deeply.

Inferior—Said of an ovary situated below the sepals, petals and stamens.

Imbricate—Overlapping.

Inflorescence—An assemblage of flowers.

Involucel—A secondary involucre.

Involucre—A collection of bracts surrounding a flower cluster or head, or a single flower.

Irregular—Differing in size and shape; shape of cell irregular in form.

Isodiametric—Having approximately the same diameters in all directions.

Labellum—The lip or lower petal.

Labiate—Lipped.

Laciniate—Cut into narrow pointed lobes.

Lanate—Covered with soft hairs; wooly.

Lanceolate—Widening above the base and gradually tapering to a point; lance-shaped.

Leaflet—One of the parts of a compound leaf.

Linear—Long and narrow.

Lobed—Margins cut deeply into lobes or segments.

Locule—The cavity of an ovary in which the ovule or ovules are contained.

Lyrate—With a large terminal lobe and small lower lobes.

Mericarp—One of the carpels of Umbelliferae; half of a schizocarp.

Mesocarp—The middle layer of the pericarp.

Mesophyll—The part of the leaf between the upper and lower epidermis; also in sepals (calyx) and petals (corolla).

Micropyle—The point on the seed at which was the minute opening of the ovule through which the pollen tube passed.

Multiseriate—Cells of hair arranged in several parallel rows or series.

Oblong—Longer than broad and of nearly uniform breadth.

Obovate—Inversely ovate.

Obtuse—With a blunt or rounded apex.

Opposite—Leaf on opposite sides of each node.

Oval—Broadly elliptical; egg-shaped.

Ovary—The part of the pistil in which ovules arise.

Ovate—Shaped like a lengthwise section of an egg.

Palmate—Resembling the open hand.

Panicle—A loose, irregularly branching inflorescence.

Papilionaceous—Having a large posterior petal, the standard, a pair of wings situated at the sides, and a pair of anterior petals, the keel.

Papillose—Bearing minute nipple-like projections; warty.

Parenchyma—Unspecialized, simple plant tissue consisting of thin-walled cells usually of cellulose.

Parietal—Pertaining to the ovary wall.

Pedicel—A flower stalk.

Peduncle—The stalk of a solitary flower or of an inflorescence.

Pericarp—The wall of the ovary when developed or ripened into fruit; the matured ovary wall.

Perisperm—The remaining tissue of the nucleus of the ovary; it is usually stored with food.

Petaloid—Resembling a petal.

Petiolate—Petiole present on leaf.

Petiole—A leaf stalk.

Pinnate—Feather-like.

Pinnatifid—Cleft or parted in a pinnate manner; pinnately cleft.

Pistil—The organ consisting of ovary, style, and stigma.

Placenta—The tissue of an ovary from which ovules arise.

Plumose—Having fine hairs on each side, like the plume of a feather.

Pubescent—Having fine, soft hairs.

Punctate—Dotted with glands.

Pyriform—Pear-shaped.

Raceme—An inflorescence of pediceled flowers upon a common axis.

Racemose—In racemes, or resembling a raceme.

Radicle—The primary root of the embryo as formed in the seed.

Rachis—The axis of a compound leaf.

Receptacle—The part of the floral axis that bears the floral organs.

Reniform—Kidney-shaped.

Reticulated—Having the form of a network.

Revolute—Edges of leaf rolled backward on the lower surface toward the midrib.

Rhizome—An underground root-like stem.

Scalariform—Ladder-like; in the form of a ladder.

Schizocarp—A fruit consisting of two united carpels which separate at maturity into two mericarps; characteristic of the Umbelliferae.

Sclerenchyma—Tissue with cell walls hard, lignified, and usually much thickened.

Segments—Portions of leaf cut to midrib.

Sepal—A leaflike division of the calyx, usually green but sometimes colored.

Serrate—Having teeth which point forward.

Sessile—Without a stalk, as a leaf without a petiole.

Sheathing—Inclosing as by a sheath; leaf invests the stem.

Silique—The seed pod of the *cruciferae* or mustard family.

Sinuate—Having a strongly wavy margin.

Spatulate—Rounded above and gradually tapering down to a narrow base; spoon-shaped.

Spike—A central rachis bearing sessile flowers.

Spinose—Spine-like, or having spines.

Spongy Tissue—Cells of the lower part of the mesophyll with large and numerous intercellular spaces.

Stamen—An organ consisting of a filament and anther, the latter producing pollen grains.

Stigma—The part of the style modified for the reception and germination of pollen grains.

Stone Cells—Sclerenchyma cells varying greatly in size and shape but usually not much longer than they are wide; walls thick, very hard, and strongly lignified.

Style—The part of the pistil between the ovary and the stigma.

Stylopodium—A thickened disk-like expansion at the base of a style, as in *Umbelliferae.*

Sublyrate—Somewhat or slightly lyrate.

Succulent—Juicy, fleshy, having watery tissues.

Suberized—Impregnated with suberin, a waxy or fatty waterproof substance.

Syncarpous—Having united carpels.

Superior—Said of an ovary situated above the sepals, petals, and stamens.

Trifid—Three-cleft.

Trifoliate—Three-leaved.

Truncate—Having the end square, appearing as if cut off.

Tunicate—Having concentric coats, as an onion.

Umbel—A flower cluster in which the flower stalks spring from the same point.

Umbelliferous—Having the mode of flowering called an umbel; a plant which bears umbels.

Undulate—Wavy; rippling.

Venation—Arrangement of veins.

Vittae—Oil secretory canals, as in *Umbelliferae.*

Wooly—Covered with soft hairs; lanate.

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John W. Parry's

List of Spices

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Allspice
  Allspice

Anise
  Anise

Black Pepper
  Black Pepper

Capsicum Spices
[Chillies, Cayenne, paprika pods]
  Capsicum Spices

Caraway
  Caraway

Cardamom
  Cardamom

Cassia
  Cassia

Celery
  Celery

Chervil
  Chervil

Cinnamon
  Cinnamon

Cloves
  Cloves

Coriander
  Coriander

Cumin
  Cumin

Dill
  Dill

Fennel
  Fennel

Fenugreek
  Fenugreek

Garlic
  Garlic

Ginger
  Ginger

Laurel Leaves
  Laurel Leaves

Mace
  Mace

Marjoram
  Marjoram

Mint
  Mint

Mustard
  Mustard

Nutmeg
  Nutmeg

Onion
  Onion

Origanum
  Origanum

- Parsley
  - Parsley

- Poppy Seeds
  - Poppy Seeds

- Rosemary
  - Rosemary

- Saffron
  - Saffron

- Sage
  - Sage

- Savory
  - Savory

- Sesame
  - Sesame

- Star Anise
  - Star Anise

- Tarragon
  - Tarragon

- Thyme
  - Thyme

- Turmeric
  - Turmeric